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Applied Science

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CONDITIONS FOR MAXIMUM LIVE-LOAD STRESSES IN THE PRATT TRUSS WITH CURVED TOP CHORD

By C. R. Young, B.A.Sc.
Lecturer in Structural Engineering

Main Diagonals

By reason of the inclination of the top chord of a truss of this type the shear in any panel is not resisted wholly by the diagonal in that panel, but a certain portion of it is borne by the top chord. It may, therefore, happen that the maximum stress in the diagonal will arise when the shear in the panel is *not* at its maximum.

Let it be required to determine the loading condition for the maximum stress in the diagonal *Cd* of the truss shown in Fig. 1. The loading to the left of the panel under consideration, *cd*, is assumed to be either a single load G_1 or a series of loads of which G_1 is the resultant and which therefore acts at their center of gravity, G_2 represents the loading in the panel *cd* and G_3 the loading to the right of the panel. These three loads are separated by two fixed spaces a and b, G_3 is situated a variable distance x from i and G_2 a variable distance x' from d.

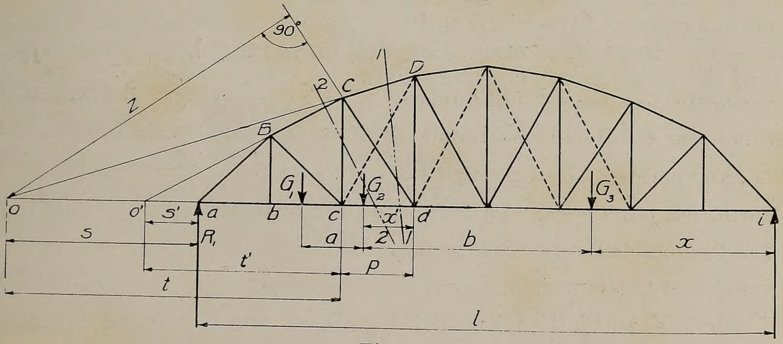

Fig. 1.

Producing *DC* till it intersects *iao* at *o*, and imagining a section plane 1—1 passed through the panel *cd*, it is seen that the stress in *Cd* is equal to the moment at *o* divided by the arm *z*. The stress in *Cd* will, therefore, be a maximum when this moment is a maximum. The moment about *o* of the forces acting on the part of the truss to the left of the section is $M = -R_1 s + G_1 (s + l - a - b - x) + \frac{G_2 x'}{p} \times t$, only the portion of G_2 which is transferred by the stringers to *c* having the effect of an applied force acting on the part of the truss to the left of the section 1 — 1.

Taking moments about *i*,

$$R_1 = \frac{G_1 (a + b + x) + G_2 (b + x) + G_3 x}{l}$$

and inserting this in the above equation for moment, we obtain

$$M = -\frac{G_1 (a + b + x) + G_2 (b + x) + G_3 x}{l} \times s$$

$$+ G_1 (s + l - a - b - x) + \frac{G_2 x'}{p} \times t$$

Differentiating with respect to *x*, and remembering that $dx' = dx$, we obtain as a condition for maximum moment.

$$\frac{dM}{dx} = -\frac{G_1 + G_2 + G_3}{l} \times s - G_1 + \frac{G_2}{p} \times t = 0,$$

Now $G_1 + G_2 + G_3$ is the total load on the span and may be represented by the single symbol *G*. Also, letting $l = np$, where *n* is the number of panels, and re-arranging,

$$G_2 = \frac{G}{n} \times \frac{s}{t} + G_1 \times \frac{p}{t} \qquad (1)$$

For ordinary rolling loads which are likely to pass over a bridge, such as locomotives and cars, the equality indicated by the last equation cannot be realized unless $G_1 = o$. In other words, **for a maximum stress in a main diagonal, there must be no load to the left of the panel under consideration.** A special loading composed of several very light loads followed by a series of very heavy ones, might need to be so placed that one or more loads would lie to the left of the panel under consideration, but for any system of loads to which bridges are ordinarily subjected this would not be true. Equation (1) may then be simplified for ordinary use by omitting the last term, thus becoming

$$G_2 = \frac{G}{n} \times \frac{s}{t} \qquad (2)$$

For the truss with parallel chords, *s* and *t* become infinite, $\frac{s}{t}$ approaches unity and (2) becomes

$$G_2 = \frac{G}{n} \qquad (3)$$

From the above it is evident that for a maximum stress in a main diagonal, there must be a *less load* in the panel than that required for a maximum shear in the panel or for a maximum stress in a main diagonal of a truss of the same span and number of panels and having parallel chords.

Vertical Posts

Consider the vertical post *Cc*, Fig. 1. Pass a section plane 2 — 2 through the truss cutting three stressed numbers, *BC*, *Cc* and *cd*. The counter *cD* will carry no stress when *Cd* is stressed. For the stress in *Cc* the moment center is o' and the arm is t'. The criterion of equation (2) may thus be made to apply to vertical posts by substituting s' for s, and t' for t, becoming

$$G_2 = \frac{G}{n} \times \frac{s'}{t'}. \tag{4}$$

The loading conditions for maximum stresses in the diagonal and the vertical post meeting at an upper chord panel-point are therefore generally different, **but if the top chord has the same slope on the two sides of the panel-point,** $s' = s$ and the criterion of equation (2) will apply to both members.

Counters

Consider the counter *Fg*, Fig. 2. The loading is assumed to not extend to the left of the panel *fg*, since, as has already been pointed out, the condition for a maximum stress in a diagonal cannot be realized, except in rare instances, with loading to the left of the panel in question. For a maximum stress in *Fg*, the moment about o'' must be maximum, since the stress is this member is the moment about o'' divided by z''. Considering the moment of the forces acting on the part of the truss to the *left* of the section 1—1, we obtain,

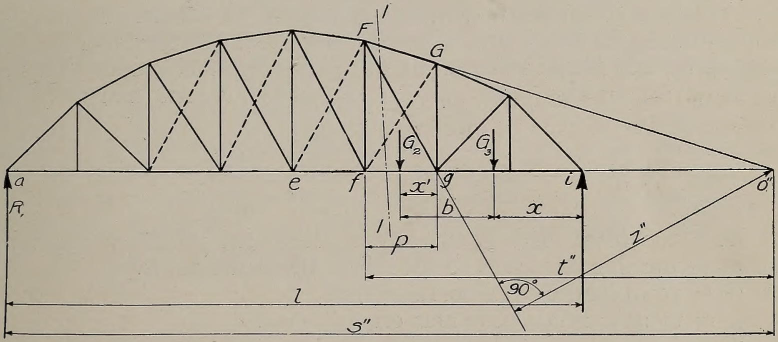

Fig. 2

$$M = R_1 s'' - G_2 \frac{x'}{p} \times t''$$

$$\text{But, } R_1 = \frac{G_2\,(b + x) + G_3\,x}{l}$$

and therefore

$$M = \frac{G_2\,(b + x) + G_3 x}{l} \times s'' - G_2 \frac{x'}{p} \times t''$$

Differentiating with respect to x and making $dx' = dx$, we obtain as a condition for a maximum

$$\frac{dM}{dx} = \frac{G_2 + G_3}{l} \times s'' - G_2 \times \frac{t''}{p} = 0$$

Now in this case $G_2 + G_3$ is the total load on the span and may be represented by G. Also, letting $l = np$, and simplifying,

$$G_2 = \frac{G}{n} \times \frac{s''}{t''} \tag{5}$$

This is precisely the same criterion as that contained in equation (2), the distances from the moment centre being in both of the measured to the *left* support and to the panel-point to the *left* cases panel in question. The value of s''/t'' being greater than unity, it follows that for a maximum stress in the counters of a truss with curved top chord, the load in the panel must be *greater than* the load accompanying a maximum shear in the panel or a maximum diagonal stress in the similar truss with parallel chords. This relation is the reverse of that already noted for the main diagonals.

Chords

Since the moment centre for the stress in any chord member is an opposite panel-point, whether the chord be curved or straight, the condition for maximum stress in any such member will be the same as for maximum moment at the opposite panel point. This is the same for trusses with parallel or curved chords and may be written

$$\frac{G_1}{m} = \frac{G}{n}$$

in which

G_1 = the total load to the left of the panel point in question.
m = number of panels to the left of the panel point.
G = total load on the span.
n = total number of panels on the span.

In words, **the moment at any panel-point will be a maximum when the load per panel to the left of the panel-point is equal to the load per panel for the entire span** and it may be shown as a further condition that the maximum moment can arise only when this equality is brought about by **the load per panel to the left of the panel-point changing from being less than to being greater than the load per panel for the entire span.**

Effect of Varying Curvature of Top Chord

In many Pratt truss spans the curvature of the top chord is not great enough to require the application of the special criteria derived above. For less than a certain curvature, therefore, the rules for maximum web stresses will be the same as for trusses with parallel chords. Some indication of the value of the limiting inclination of chord segments is afforded by the fact that for a truss of the type shown in Figures 1 and 2, having 8 panels of 25 feet each, a hip depth of 30 feet, and subjected to any of the steam railway loadings of the Dominion Government specification the special rule for maximum diagonal stresses contained in equation (2) first becomes necessary for the successive panels when the slopes of the top chord segments are as follows:

Chord Segment	Slope, Vertical to Horizontal
BC	5½ in 12
CD	3 in 12
DE	1½ in 12

To render the application of equation (2) necessary for the diagonals in *all* panels up to the centre, the truss under consideration would require to have a depth of 51 feet at the centre, or slightly over one-quarter of the span. A truss of such proportions would, for several reasons be undesirable, in general. While the top chord segments in the end panels may be inclined with sufficient steepness to bring into operation the special criterion of equation (2), the rapid reduction of this slope near the centre soon renders possible the application of the simple rule for parallel chord trusses. Since the values of s and t are independent of the truss depth, the less the depth at the hip, the less the slope of the chord segments at which equation (2) becomes necessary. Its application will be most frequently required when the top chord panel-points are on a regular curve passing through the end supports, that is for the bowstring truss.

In case of doubt whether the curvature of the top chord is great enough to require the application of the special criteria derived above, it is best to employ them, since they are perfectly general and apply to trusses with any degree of top chord curvature. As has already been shown, the rules for parallel chord trusses are merely particular cases of the general ones herein established.

References

References—For a more extensive treatment of the subject, the student is referred to the following works:

Edgar Marburg—Framed Structures and Girders; Vol. 1, Stresses; Part 1.

Burr & Falk—Design and Construction of Metallic Bridges.

Johnson, Bryan & Turneaure—Theory and Practice of Modern Framed Structures; Part 1, Simple Structures

LITERATURE AND MINING

By J. C. Murray, B.A., B.Sc.*

Samuel Pepys was an official in the Navy Department in the reigns of Charles II. and James II. He was, also, an amazingly candid diarist. His diary, obviously never intended for publication, was written in a short-hand of Pepys' own devising. It covered the period 1660-1669. By accident it was not destroyed and it was included in the gift of books that Pepys bequeathed to Magdalene College, Oxford. Not until early last century was the shorthand deciphered.

Frequent illuminating allusions to mining matters occur in the

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*Editor of *The Canadian Mining Journal*," in an address to the Engineering Society, the first part of which appeared in "Applied Science" for October.

diary. Nova Scotia figures in several of these. In an entry for May 13th, 1667, we find this: "This morning comes Sir. H. Cholmly to me for a tally or two; and tells me that he hears that we are by agreement to give the King of France Nova Scotia, which he do not like: but I do not know the importance of it." A few months later, however, Pepys received more light, for he complains of the matter again, and characterizes as shameful the giving away of Nova Scotia, "which hath a river 300 miles up the country, with copper mines more than Swedeland, and Newcastle coals, the only place in America that hath coals that we know of." A river 300 miles long would, if crowded into Nova Scotia, assume roughly the shape of a closely coiled serpent. Also rumours of coal have come from other parts of the continent; but Mr. Pepys was not a stickler for trifles.

During the year of the great fire of London, 1666, Pepys notes the extraordinarily high price of coal in the city. The price per chaldron (25½ hundredweight) was £3 3s., and it must be remembered that the purchasing power of money was thrice as great then as it is now. But early in 1667 worse befell. Pepys, in the act of purchasing some newsbooks at Westminster Hall "did hear everybody complain of the dearness of coals, being at £4 per chaldron, the weather, too, being become most bitter cold, the King saying to-day, that it was the coldest day he ever knew in England." The next day, sad to relate, was still colder. "This day," groans the excellent Samuel, "was reckoned by all people the coldest day that ever was remembered in England; and God knows! coal's at a very great price!" Harried as the coastwise colliers were by the Dutch fleet, it is not surprising to read that coal went up to £5 10s. in the following June.

A few sentences from his description of the methods used at the Royal Mint, and we shall have done with Mr. Pepys.

On the morning of May 19th, 1663, Pepys, to use his own good phrase, was "up pretty betimes." With a few friends he was shown over the Mint by the controller, and he takes pains to set down his impressions. He tells, among other things, how he "saw the manner of assaying of gold and silver, and how silver melted down with gold do part, just being put into aqua-fortis, the silver turning into water, and the gold lying whole in the very form it was put in . . . . which is a miracle; and to see no silver at all, but turned into water, which they can bring again into itself out of the water, " Discussing all these things afterwards at dinner, the controller told his guests of one dishonest laborer who clipped coins and swallowed the clippings "down into his belly,and so they could not find him out." The thief was later induced to confess. His thievings amounted to £7. Another artisan made dies that produced facsimiles of old, worn coins, and thus gained 50 per cent. on his investment.

It is not inappropriate here to glance for a moment at Lord Macaulay's vivid description of the condition of the mineral industry of England just about the period to which we have been referring. Tin was one of the most valuable products of the mine, the output from Cornwall being about 1,600 tons annually. Copper, however was altogether neglected. Rock salt was not worked. "The salt which was obtained by a rude process from brine pits was held in no high estimation. The pans in which the manufacture was carried on exhaled a sulphurous stench." In fact, the residue was hardly fit for human consumption, and, as it was supposed to induce scorbutic maladies, it was used only by those who could not afford to buy the more expensive French product.

Since the manufacture of iron implied the wholesale destruction of forests wherefrom to obtain the necessary charcoal, the industry was not encouraged. In fact, nearly all the iron used was imported, not more than ten thousand tons being made in Great Britain annually, a quantity equal to the output of one large modern furnace in less than a month. The art of using coal or coke had not, of course, been thought of.

Coal, the most important of all minerals, was very little used in manufacture. Few mines were worked that were not easily accessible by water, and London, so Lord Macaulay believes, consumed at least half of all the coal mined. As the capital is credited with requiring about 350,000 tons annually in the reign of Charles II. (and this quantity was thought to be fabulously large) one can compute the total without a ready reckoner.

It would be pleasant, of course, to continue multiplying such citations and quotations. Standard English literature, both prose and poetry, abounds in facts, fancies, and metaphors drawn from mining and metallurgy. Our vocabulary has drawn many cogent phrases and words from the mine. The whole course of history has been colored by man's desire for the products of the mine. The arts and the industries are based upon the miner's labor. Our remotest ancestors, shortly after they outgrew their tails, took to smiting each other with roughly smelted weapons of iron and copper. At the same time—I have to ask you to take my word for this—the female of the species recognized the decorative value of polished metals. And I doubt if this made for peace.

It is, I take it, quite superfluous to quote from Holy Writ. You all know of that first artificer, Tubalcain, of the metallic embelishments of the Temple; of that oft misquoted and magnificent chapter in the Book of Job; and last, of the specifically mineralogical terms in which both places of future abode are described in the last book of the accepted canon.

All this, I doubt not, would be a work of supererogation. It will suffice for me to assure you that there are equally available and more modern works that can be used with profit. The assays of T. Sterry Hunt, the volumes of Sir William Dawson, many of the pamphlets of Dr. Henry Youle Hind, not to mention other noted Canadian scientists are pre-eminently worth while to the mining man. Moreover, when he wishes other stimulation, he can turn with profit to the pages of Parkman, who is to my mind the best of historians; or to Prescott, who deals with more southerly latitudes. In both, particularly in the latter, he will find that the romance of mining plays a considerable part.

The broad truth that I wish to impress upon you is that general reading is vitually necessary through all stages of our mental development. I fear that I have succeeded in submerging this truth in a flood of extraneous matter. Nevertheless it is a truth that cannot be ignored. The mining man who reads wisely and well is a better citizen than the mere technologist. He is also the better technologist.

THE BUSINESS SIDE OF CENTRAL STATION WORK

By Wills Maclachlan, B.A.Sc.*

The profession of engineering is divided into a number of different parts. The work of the civil engineer, the mining engineer and the architect, is well known, but the exact work of the electrical engineer is not so well defined. First, I will try to give some idea of the work that an electrical engineer is called upon to do. Electrical engineering naturally divides itself into two main branches. First, the design, manufacture, construction and sale of electrical appliances. By this I mean any appliance that is used in the handling of electricity whether it be a transmission line, a large generator, or a flat iron. The second division of electrical engineering is the generation, transmission, distribution, and sale of electricity. If you purpose following the profession of electrical engineering, your energies in later years will be confined to one or more of the sub-divisions that have been mentioned, but it is the intention to dwell here on the latter of these divisions, namely, central station work.

The work of the central station is divided into pure engineering and business. Under the branch of pure engineering we find the work of the general superintendent and all who are responsible to him, and in large central stations we also have the experimental side under the engineering department. Then we come to the business side of the central station. There is a great tendency among students and young engineers to belittle the office work and spend their energies on the practical side of their training. This is a great mistake, and to show some of the objects of the office work of a central station is the aim of this paper.

Let us examine briefly the accounting system of a modern central station. The line department, meter department, office staff, sub-station and power-house are doing work every month. It is costing a certain amount of money to operate the central station. Its modern accounting system tries to sub-divide the cost of these different operations and this is obtained by using what are called accounting numbers. In the central station with which the writer is connected, we use 61 account numbers. These numbers cover the wages of the power plant, the fuel used in the power plant, the water used for power, the oil and waste in the power plant, etc. Again there are pole rentals, maintenance of poles, maintenance of overhead lines, maintenance of underground circuits, the rental of underground conduits, maintenance of transformers, maintenance of meters, etc. Further classification involves new business salaries, canvassing, advertising, salaries of head office, salaries of local office, printing and stationery, head office expense, etc. By thus keeping the expense of each of the different operations entirely separate on pay rolls, invoices, stores reports, we are able at any time during the year to tell exactly how much each of the different divisions is costing. For instance, if the cost of maintenance of the overhead lines is excessive, we are able to put our finger on the specific item, that requires readjustment, enabling the management to proceed at once to bring this expense down to a reasonable amount. Then these different operating expenses are grouped together under the main divisions: Total Expense Power Plant, Total Maintenance Power Plant, Total Expense Transmission, Total Expense Distribution, Total Utilization Expense, Total New Business Expense, and Total General Expense.

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* In an address to the Engineering Society, Oct., 20th, 1912.

By grouping all these expenses for the month and placing them in total on a form, we are able to compare, for example, October expense with that of September, August or July of this year, or with the expenses of corresponding months last year. If it is evident that a certain expense this year is entirely out of proportion with the corresponding expense last year, we immediately seek the reason. This may be uniquely recorded on cross section paper, plotting dollars and cents as ordinates and the months of the year as abscissas. At the beginning of each year curves are plotted showing the last year's expense and then on this same cross section paper the expense of the current year is plotted from month to month. In this way it may be seen at a glance how each expense is running.

It is expedient now to explain the capital charges and the manner in which this part of the business is operated. You will recognize that, if you have to extend your system into a new part of the town, for instance into a new manufacturing plant needing power, and into the workmen's houses near the plant, if your lines are not near at the time, it is hardly fair to build these lines and charge them to operating expense. In a case like this, we make out an estimate of the cost of building the new lines. At the beginning of each year we send in all the estimates for building lines that we think will be necessary during the year. The executive office passes on these estimates, and appropriates money to do this work. This appropriation is given a number and each of the estimates under this appropriation is given a job number. For a certain central station you might have an appropriation number 100, covering all your capital expenses for the year. Under this appropriation there will be jobs 1, 2, 3, 4, 5, 6 and as far as your different divisions go. Under these divisions you have itemized work, such as the extension of your system for a block that will cost about $80.00 or $90.00, which will be designated, say No. 4A. An extension of the system in another part of the town will be called 4B., and so on. In this way, as in the case of the account numbers, we keep each separate extension by itself, and can readily tell how much it is costing. This gives us data to work on for future estimates, and also affords a check on whether the work is being carried on satisfactorily or not.

The manner in which the consumers' ledger is handled is also interesting. In this ledger we carry the accounts that we have against all our different consumers. This ledger is ruled horizontally about 45 lines to the page, each line representing a different consumer. Vertically for each month we have, columns for Electric Metered, Electric Non-Metered, Power, Street Lighting, Property Rents, Total Earnings, etc. Then on the cash side, we have Cash Received, a column for the Date of Receipt, Discounts and Delinquents. The accountant in making out the bills for the month takes the meter reader's book. This is a loose leaf book, containing all the readings of the meters on the consumers' premises, each consumer having a page. He works out from the meter readings, the amount of power the consumer has used during the month. He then multiplies this by the rate charged and places it in the consumer's ledger and on the bills. On the bill he also marks the discount allowed and the net bill. Then when this bill is paid he marks in the amount paid on the correct column noting the date and also noting the discount allowed. These two columns should equal the earnings shown when the bill was made out, so to balance this ledger, we take the total out-standing for the previous month, less cash and discounts, to equal the delinquents, Then delinquents plus all earnings should equal the total outstanding for the present month. This shows a very simple ledger, but the simpler the ledger, the better it is as there are so many different accounts to be kept in it.

Taking up now some of the work that is carried on in the office, let us look into who should constitute the office force. First there is the *cashier*. This is the man who has charge of the office. He is responsible for all moneys received and for the keeping of the books. He is also responsible for the filing of all records, etc. Then we have an *office assistant*, whose duty it is to aid the cashier in all work possible, to look after the stores' reports, and to act as a general utility man in the office. These two men in the average size central station will look after all complaints, signing of contracts, and the sale of appliances, etc., to the consumer. Third, the *stenographer*, who writes out all correspondence, keeping track of filing system, making out reports regularly for the executive office, typing and addressing the consumers' bills. Fourth the *meter-reader*, whose duties it is to read the consumers' meters once a month, and to install new meters. The average meter-reader can read about 150 meters a day, and hence may be expected to have considerable spare time, and in this time he is usually required to act as a clerk to the line foreman. Fifth, the *manager*. His duties are to keep a general supervision over all work, and to act in an advisory capacity between the office staff and line force. He is the representative of the company in all dealings with the public.

This in a short way will give an idea of the office staff of an average sized central station. All the records in the central station should be kept on file so that they are accessible at all times. This is very important, as in filing duplicates, etc., it is often found necessary to refer to a record that is perhaps a month or a year old. We find that by using card system, Shannon files, and vertical files, we can keep things in good shape.

Let us investigate the events that occur when a consumer enters the office and asks to be connected to the line. First he is required to sign a contract for the supply of electricity. This contract is made out on a regular form by one of the office staff and the consumer's signature is witnessed by him. After the contract is made out, an instruction order is made out instructing the line department to do the work. This contract being made out in duplicate accompanied by the instruction order is submitted to the manager for his consideration. The manager then signs the contract for the Company, and approves the instruction order, placing on the latter the accounting number to which the work is to be charged. A copy of this instruction order is kept on file in the manager's office, the original along with the contracts, being placed on the line foreman's desk. The line foreman on receiving the order, checks it with the contract, has his men run the service and has the meter-reader install the meter. At the time the meter is installed the meter-reader examines the house, estimating the number of lights and getting every detail with regard to the service. When the work is completed, the line foreman places on the instruction order the amount of material used to do the work, and amount of time used in doing it, the meter number and reading, number of lamps in the house, and number of transformer to which the house service is connected. He then initials the order and returns order and contract to the manager's desk. The manager then checks completed order and contract, and if everything is in right form he takes off his file the copy of this order and destroys it. He then returns the contracts and order to the office. The office assistant then takes the instruction order, works out what the material costs and files the order for the monthly return. A meter reading sheet is then made out from the contract and instruction order, and is placed in its right place in the meter reader's book and the name of the consumer is entered in the consumers' ledger. The contract is then filed in the contract file, and a copy mailed to the consumer. At the end of the month all the instruction orders are grouped together and on a stores' report the cost of the work is returned to the executive office showing the cost of material used in different jobs during the month. I do not think it is necessary to go into all the details of the different forms that are required in the office. We use some 34 different forms at the present time, and I will simply mention that there are separate forms for ordering material, returning invoices, petty cash reports, consumers' ledger reports, stores reports, pay rolls and a number of other forms to the executive office. These forms go through a regular set routine, and in this way we save a great deal of time in being able to do the work quickly and at the same time without any mistakes.

We will next touch on the new business side of the central station work. It is very important before starting in a campaign or canvass for new business, to know your territory. This is first done by having a card system made out, having one card for every house in town. On this place different details that are required, with regard to the house. It is well to have one color card for the consumers and another for non-consumers. If the central station is large enough a solicitor is employed to go out and interview prospective consumers. Let me touch for a minute or two on the training and work of the solicitor. I do not know of any position in the central station that would give better training in central station work than the work of the solicitor. This man should be able to meet people, talk to them in an ordinary gentlemanly way, explain all the details that are required in a way that they will understand, leaving out all technical language. He should be able to go into a store, lay out that store for lighting and tell the prospective consumer about what this average bill will be for a year. You will think I am asking a great deal of a solicitor, but it is not a hard proposition to lay out an average store for lighting and most of the data can be obtained from tables. Above all things, the solicitor should remember that he is the employee of the central station that is soliciting business from the public, and the public judges the central station by the employees that they see. Hence just so much as the solicitor gives a good impression, so much will the public have a good impression of the central station. This work of soliciting develops a man in meeting the public, in telling his story in a concise and convincing way, and trains him in that most important study, namely the study of human nature.

The advertising of the central station is a very important detail. In good advertising the most important thing to remember is to tell one thing at a time, have your advertising a little bit different from that of everybody else, and educate the public in the many uses of electricity.

Let me now touch briefly a subject that is just beginning to be recognized as a very important one. Namely the collection and analysis of statistics. By collecting the statistics of your central station, I mean as follows:—Take the total revenue for a period say six years, working out a curve showing the growth of revenue from year to year, take your total revenue for a year, find you what per cent. each month's revenue is of the total and plot a curve showing variation from month to month. Take from the sub-station or power-house reports the total K.W-hours used each month and plot them, and on the same cross section paper plot the monthly peaks. Take the revenue from your lighting consumers, and the revenue from your power consumers, and plot them from month to month. Then from the previous year's records plot the per cent. that each month is of the total revenue under meter, power, and flat. From these and other curves that might be mentioned, you will be able to analyse from an engineer's standpoint the workings of the central station. These curves give you an insight into the real workings of the central station that you can get in no other way and with these curves and these statistics as a basis, if you will give the question of rates and forms of contract the study that it should get, the knowledge of rates in the future should be on a far better basis than it is at the present time.

Before closing, let me outline the duties of the central station manager. First, what should his duties be to the staff? He should try to know the details of the duties of every member of the staff, so that he can lend help and advice at any time. He should gain the confidence of his staff in such a way as to bring about that ideal of working, namely, *esprit de corps*, and team work, that is absolutely necessary in modern business.

Second, in regard to his duties to the executive office, he should see that all orders from the executive office are carried out in detail. If he does not understand these orders he should find out the why and wherefore immediately, and he should be loyal to the executive staff and try to instill into his staff that loyalty that is necessary. In regard to his duties to his consumers, the position of the modern central station has changed greatly in the last few years. The old motto of Cornelius Vanderbilt of "Public be Damned," has long since passed away and the modern motto of "We Serve," is coming to the front. If the consumer comes in with a complaint, investigate that complaint and take the consumer's word that he is telling the truth. After careful investigation, if there is a doubt in the case give the consumer the benefit of the doubt and you will find that by acting fairly with your consumers, you will get better results than by antagonizing them.

The duty of the manager to the community might be broadened out to refer, not only to the central station manager, but to engineers in general. At the present time the engineer is of too quiet a disposition. The professional men in other branches, namely the doctor, the lawyer, the minister, etc., are taking their places as good citizens and are helping the community as a whole. Up to the present time the engineer has not come forward as a broad minded man and as a citizen. He has received his training in looking at things with a critical eye, and from the more practical standpoint. Do you not think that his advice in matters pertaining to engineering works would not be acceptable to the community? We find hundreds of thousands of dollars wasted on work that has been abandoned due to the fact that good sound engineering advice was not obtained in the first place. You say that the community by paying for it, can obtain good engineering advice, but in municipal councils and on our legislatures and in parliament, we find doctors, lawyers and business men working for the community, but to find an engineer in any one of these capacities, is a very rare thing. Why should the engineer as a professional man, as a business man and as a good citizen, not come forward and lend his help in the governing of the municipalities of the country. If you will, as I hope some of you will, go into central station work and become managers or local managers of central stations, you will find that you will gain a great deal of good for yourself, for your company, and for your community, if you will go into the Board of Trade or Chamber of Commerce, and lend your aid to assist movements in your town and help in moulding and educating the public mind up to good ,sound, broad-minded, principles.

You must remember that the profession that you are now entering is just in its infancy. Thirty years ago the profession of electrical engineering was practically unknown, and electricity was confined to the laboratory. You must remember that the great stride that has been made in this profession in the last three decades will be surpassed by the stride that will be made in the next three, and it rests upon you and other men who are entering upon this profession to see that these wonderful developments are carried out. Remember, that Canada's strength lies in the value of the enormous water powers that are scattered over the whole country. The old motto was "We have iron and fire, the hand cannot go back on the dial of time." But the new motto is "We have iron and fire and power, the hand of time cannot go back on the dial of time," and hence we have the united trinity to aid in making Canada one of the nations of the world." We are ancients of the days, but in the morning of the times in regard to electricity." In taking up your statistics, you should remember that it is not only the purely technical work to which you should devote your attention—and I would not belittle the technical work, for I well understand and appreciate the enormous amount of labor required to perfect the design of electrical apparatus in the future and to operate the large transmission lines in a more efficient way than they are at the present time—but you must be able to see clearly the value of the office work and the value of the field work, and if you can combine the detail information that you can get from the statistics of the office with the knowledge of the right way of designing and the right way of operating and add to these that very important element, the human touch, you will do a great deal to elevate the profession of electrical engineering, to enrich and strengthen the position of your country and to have the personal satisfaction of doing something worth while.

In this paper I have simply tried to open up different lines of thought regarding central station work so that you will have some conception of the work of the engineer in the business side of the central station.

IRRIGATION*

By H. M. Goodman, '13

Irrigation may be defined as the systematic application of water to land with the object of promoting present or prospective growth. The artificial watering of crops in which the farmer and the engineer unite in the employment of methods whereby water may be applied in the easiest, least expensive and most surely uniform manner, i. e., by the action of gravity and natural flow, is the result. Ditches are constructed which lead water from the source of supply, and are so aligned and graded that the water flows through and from them into minor channels, and from them in turn to distributary channels, leading finally to the fields by means of ploughed furrows or otherwise. Agriculture by irrigation produces the most luxuriant and abundant crops, since in the arid and semi-arid regions, where artificial watering is essential, sunshine is ever present, and water is applied only when needed, and always in exactly the amount desired. The notable difference between a dry-land farmer and an irrigator is that the former relies on Nature for his entire supply of moisture, while the latter buys and pays for the requisite amount.

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* With references to the Dominion Government Irrigation Belt in Saskatchewan.

Hydrographical investigations have to be undertaken in order to find out whether sufficient water can be acquired for irrigation purposes. These operations consist of obtaining full information regarding precipitation, run-off and stream flow.

Precipitation

Where climate and soil are favorable to the growing of crops, it is evident that the necessity for irrigation depends on the available amount of precipitation. For this reason it is necessary to examine carefully the records of precipitation in the district, extending over a number of years in order to arrive at a conservative estimate of probable precipitation. In practice it is always prudent to base the estimate on minimum values, since precipitation is known to vary perceptibly from year to year. It is also necessary to approximate the maximum precipitation which may occur, in order to make the design sufficiently strong to withstand it.

Run-off

The name is applied to the quantity of water which flows in a given time from the catchment basin of a stream. It includes rainfall, springs, etc. Run-off from a catchment area may be expressed either as the number of second-feet of water in the stream draining that area, or as the number of inches in depth of a sheet of water spread over the entire catchment. As run-off bears a direct relation to precipitation it would appear that, knowing the amount of rainfall and the area of catchment basin, the amount of run-off can be directly ascertained.

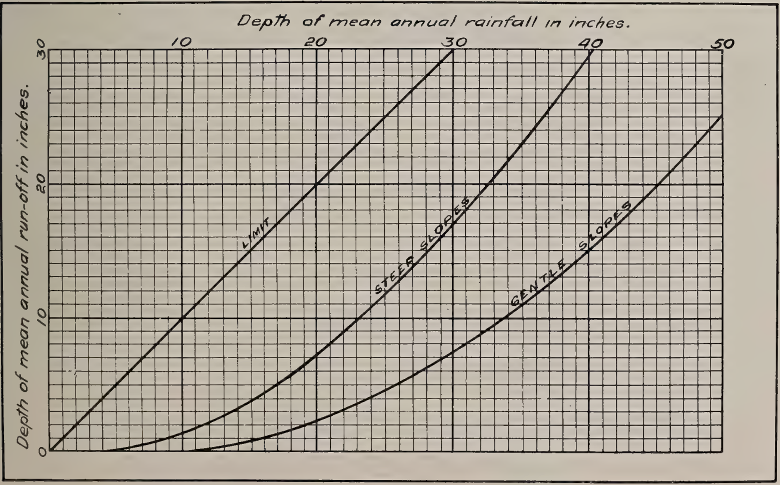

Fig. 1—Relation of Run-off to Rainfall

This is not the case, however, for the amount of run-off is effected by varying climatic and topographic factors. The climatic influences bearing most upon run-off are, the total amount of precipitation, its rate of fall, and the temperature of the earth and air. Within a given drainage basin the rates of run-off vary on its different portions; thus, in a large drainage basin the rates of run-off for the entire area may be low if the greater portion of the basin is nearly level, but at headwaters of the streams where the slopes are steep, the rate of run-off will be greater.

For consideration of the above the curve of Mr. F. H. Newell, shown in Fig. 1, gives graphically, an excellent means of obtaining the average run-off due to average precipitation.

In irrigation reconnaissance surveys this curve is very useful and is at present used by Dominion Government parties in their work.

Stream Flow

Where the catchment basin is comparatively level, well covered with timber and grass, and the soil deep, the rate of run-off is consequently low and the streams are nearly constant in their discharge, being subject to few and not excessive flood rises. This occurs where, as in most cases, the larger portion of water reaches the streams by seepage. Where the catchment basin is precipitous and barren the regimen of the stream is the reverse of the above—very little water soaks into the soil, and after a heavy storm most of the water runs off in a very short period, resulting in great floods.

Mean Discharge of Streams

When definite data of the annual discharge of a stream are not available they may be obtained approximately by multiplying the depth of run-off in inches by the area in square miles of the catchment basin. While these quantities will furnish valuable information regarding the mean annual discharge of the stream they fail to indicate the mean discharge during different months and especially during the irrigation period. For this purpose a discharge curve is important, and if there be none for the stream in hand, it will be necessary to make a few gaugings at different stages of water.

Theory and Practice of Measuring Discharge

There are three distinct methods of determining the surface flow of streams.

(1) By measurement of slope and cross-section and the use of Chezy and Kutter's formulæ. This method is very rough and is made use of only in special cases, such as in obtaining an idea of discharge during flood time where the high water marks can be easily determined, or arriving at an estimate of discharge of a spring creek when no water is flowing.

(2) By means of weirs, which include any device or structure that by measuring its depth on a crest, or sill, of known length

and form gives the flow of water by the use of the well known Francis' formula.

This method is used when the stream is small, and when the depth of water in the stream is too small for measurement with a current meter. If the conditions of Francis' formula are observed this method is very accurate.

(3) By measuring the velocity of the current and its cross section. For this method a current meter is chiefly used. In making a measurement with a current meter, a number of points, called measuring points, are located in the plane of the measuring section, at which points observations of depth and velocity are noted. The measuring points divide the total cross-section into elementary strips at each end of which these observations of depth and velocity are made. The discharge of any elementary strip is the product of the average of the depths at the ends, the width of the strip, and the average of the mean velocities at the two ends of the strip. The sum of the discharges of the elementary strips is the total discharge of the stream. If the instrument is kept in good repair the results are considered fairly accurate.

For stations with permanent beds it is possible to prepare from the data collected, station-rating tables, each of which gives for its station the discharge corresponding to any stage of the stream and also, when applied to the daily gauge heights, gives the daily discharge.

The basis for a station-rating table is a rating curve which shows graphically the discharge corresponding to any stage of the stream, and is usually constructed by plotting the results of the various discharge measurements, with gauge heights as ordinates and discharges as abscissas. These points define the curve which can then be drawn in. Since the discharge is the product of two factors, area and mean velocity, any change in either factor will produce a corresponding change in the discharge. The curves of area and mean velocity thus furnish valuable assistance in studying the accuracy of the measurements, and determining the true location of the rating curve. These curves are defined by plotting gauge heights as ordinates and areas and mean velocities as abscissas.

Now, by the use of the discharge curve, as shown in Fig. 2, and accurate gauge height readings, a fair idea of the water flowing through daily is arrived at, and hence the amount of water available for irrigation purposes is determined.

For the engineer investigating the feasibility of an irrigation scheme as regards available water he can secure most of the information up to the present from the Hydrographic Service.

In cases where the data gathered by the Hydrographic Service do not cover the source of supply from which diversion is proposed, the engineer should ascertain the approximate drainage area above the point of diversion, the nature of the land composing it, i. e., whether the slopes are steep or flat, timbered or bare, the kind of soil, whether likely to absorb a large proportion of precipitation. He should obtain all information possible regarding precipitations, more particularly concerning its physical division into rain and snow. Then the peculiarities of flow in the source of supply should be carefully considered, it should be accurately determined whether or not the stream has a constant flow and what is the nature of the feeders that maintain it. In case the flow is periodic an effort should be made to ascertain the average duration of the periods each year, and calculations as to the quantity of water at flood stages should be made by means of the Kutter & Chezy formulae from water marks observed.

Similar observations relative to the size and slope of the channel, erosion due to flood water, and the nature of the bed and banks, are often of value in estimating the water supply in a stream with which the engineer is unfamiliar.

Irrigable Area

In reporting upon the area it is proposed to irrigate careful consideration should be given to the nature of the land with relation to its slope, ascertaining the approximate fall in feet per mile, together with other characteristics of the surface; and likewise with relation to the composition of the soil together with the abundance and quality of the vegetation found thereon, and the kinds of growths best adapted to it under irrigation.

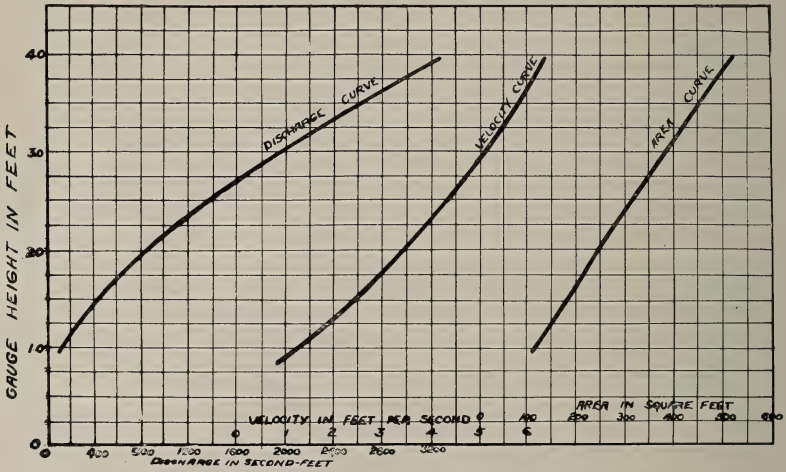

Fig. 2—Discharge, Area and Velocity Curves

These data are essential to the engineer in determining the system of irrigation most suitable to the particular case, together with the probable cost per acre of constructing a satisfactory scheme.

Reservoiring Facilities

In the province of Saskatchewan (Dominion Government irrigation belt) in the majority of cases at the present time the source of supply is a stream or coulee having a periodic flow only, or one in which all the low water flow has been previously granted. This makes the inclusion of some system of reservoiring necessary if the scheme is to be fully successful. In such cases it is necessary for the engineer to look carefully into the storage facilities on or in the vicinity of the land to be irrigated.

The different methods of reservoiring in Saskatchewan are:

1. Dyking System.—This is the least expensive and least efficient method of reservoiring since the land that it is actually intended to irrigate is completely under water during long periods. It is frequently the only method available, however, without very expensive outlay. It is applicable to comparatively smooth flats, having a fall of not more than 10 or 15 feet to the mile, and succeeds very well when used in connection with the irrigation for hay. The dykes are most successfully constructed on contours so that the high water mark on one reaches the bottom of that next higher. With this system of irrigation a thorough system of drainage ditches is required.

(2) Reservoirs Within the Stream Bed.—These are obtained by damming the stream valley, and are consequently more expensive than dyking systems. The principal difficulties to be overcome are in the provision of dams sufficiently strong to resist freshets and of such construction as to permit of the safe passage of excessive flood water through suitable wasteways. This method is used when reservoiring is not practicable in the vicinity. When the fall of the stream valley is slight it is possible to hold back quite a large amount of water by the construction of a dam.

(3) Storage Basins Outside the Stream.—These make the most satisfactory system wherever they are feasible at a moderate expense. The difficulties in the way of construction are usually much greater than in either of the other cases, owing to the cost of dams, intake ditches and proper outlets arising from the fact that a sufficient elevation must be obtained for the reservoirs to deliver water on the highest point of the irrigable land, making it necessary to have the intake higher up the stream with a resulting longer ditch. Furthermore, the intakes must be of large capacity if they are to utilize flood water to the best advantage, as they should be able to fill the reservoir within the usual flood period of each year.

The reservoir problem is one of great importance in determining the probable success of any such irrigation system and should be carefully investigated before an opinion is formed as to the feasibility of the proposed scheme.

Duty of Water

Duty of water is a term used by irrigation engineers to express the amount of work that water does or may be expected to do in irrigating crops, and is one of the first items of importance in designing an irrigation system.

On this duty of water for a given soil and region oftentimes depends the financial success of an irrigation enterprise. As water becomes scarce its value increases. The estimated cost of an irrigation project therefore depends on the amount of water the land will require. The dimensions to be given the canals and reservoirs depend likewise on this factor. The duty of water varies primarily with the crop; it varies also with the temperature of the locality and conditions of the ditches. The period of time during which water is applied to the land for irrigation from the time of first watering until the last is known as the irrigating period.

Units of Measurement

The duty of water is expressed usually in either of the following ways:

(1) By the number of acres of land that a second-foot of water will irrigate; and,

(2) By the number of acre-feet of water required to irrigate an acre of land. In considering the duty of water it should be noted whether it is computed from the quantity entering at the head of the canal or the quantity applied to the land, since the losses by seepage, evaporation, etc., in the passage of water through the canal are considerable.

The duty of water in Saskatchewan is a matter of extreme doubt, but at present it is estimated that one second-foot during irrigating period at the head will irrigate 150 acres. These figures have no doubt been acquired by experiment in parts of the province where the water is chiefly used in the ranching district for raising hay. The duty would, of course, be different were the soil required to grow other classes of vegetation. The irrigating period in Saskatchewan is from about May 1st to Sept. 1st, the service periods varying with the kind of crop. To handle water economically a head must be carried sufficient to furnish the requisite velocity of flow to the most remote points.

If irrigation were in progress at the same time along all points of the same canal sufficient water would not reach the lower portions to properly water the bed of the ditches. In the operation of a canal system, therefore, it is customary to divide the laterals into sections and to permit of the irrigation of one or several sections only at a time. This is done by establishing a system of rotation, giving each section a definite service period under different heads.

Classes of Irrigation Works

Irrigation works may be divided into two classes: gravity and lift irrigation. The former includes all systems by which the water is conducted to the land by the aid of gravity or natural flow. Among them are, perennial canals, periodical and intermittent canals, inundation canals, and storage works.

Lift irrigation includes those forms in which the water reaches the land, not by natural flow, but by mechanical means. This method of supplying water is seldom made use of on account of high cost, and is therefore used only when the supply of water is known to be ample and the soil to be covered warrants it. There are at present no schemes in Saskatchewan where water is pumped.

Irrigation Canals

The conditions required to develop an irrigation canal are these: It shall be carried at as high an elevation as possible to provide sufficient fall for the irrigation of land to a considerable distance. It should be fed by some source of supply as would render it a running stream. It should also have such a slope and velocity as to reduce to a minimum the deposition of sediment and the growth of weeds. Finally, its velocity should be the greatest possible in order that cross-section may be reduced to a minimum for a given discharge.

Where the precipitation is small, occurring during a short period of the year, resulting in intermittent or periodic flow of streams, canals of this class, or storage works must be employed. This is largely the case in Saskatchewan, and the works constructed are mainly for diverting water from such sources. Intermittent and periodical canals are usually small in dimensions, commanding relatively small areas of land, and are generally employed by individual farmers for the utilization of the waters of some stream which may be safely relied upon for continuous supply, occurring through spring storms and melting of mountain snows.

Storage works receive their supply from intermittent streams carrying sufficient volumes of water in times of flood.

Inundation Canals

These might also be called flood-height canals, as they are dependent for their water supply on the height of flood rise in the river or stream. There are numerous schemes in Saskatchewan where the water is brought to the land by these canals. This type of canal rarely requires permanent headworks for the control and admission of water to its channels, its head consisting of a simple cut through the river-bank or the ridge which separates the stream from the low-lying surrounding lands. As they depend upon flood rises for their supply the beds of these canals are generally at some height above the beds of the rivers from which they receive their supply, and usually at the level of mean or low water, so that when these streams are not in flood they do not receive any water. Although many of the schemes in Saskatchewan are of this nature they have not proved very satisfactory for frequently the flood does not rise high enough to give a sufficient head with which the low-lying lands may be irrigated, especially so when the ditch is of some length. If, however, some sort of a dam be thrown across the stream the irrigator may then be more certain of his water supply. However, as this means extra cost for the installation, its construction is frequently not warranted since the area to be irrigated may be small and the cost per acre high.

Perennial Canals

These canals derive their supply from perennial streams or from storage reservoirs. They are divided into two classes, according to the location of their headworks, viz., high line canals and low service canals. The former are usually of moderate size and are designed to irrigate lands of limited area which lie adjacent to the foot of the higher hills. They are generally given the least possible slope in order that their grades may remain high. In such canals it is necessary to locate the headworks high up in the stream.

There are many schemes in which the type above mentioned is made use of in Saskatchewan and which are now working most satisfactorily.

Parts of An Irrigation Canal System

(1) Source of water supply.
(2) Irrigable lands.
(3) Main canals.
(4) Headworks and regulating works.
(5) Control and drainage works.
(6) Laterals.

The source of the water is the first consideration in designing an irrigation scheme. The relation of this to the extent of irrigable lands must then be considered.

The headworks usually consist of a diversion dam or weir with regulating gates to control the amount of water to the canal entrance, and of a wasteway for discharging surplus water. Control works are built along the canal line for the regulation of the amount of water admitted to the laterals (or branch canals), for the wasting through spillways of superfluous water including that received from side drainage. Falls, or drops, may be constructed to neutralize any excessive slope of the country.

The laterals are the channels which receive supply from the main canal and which in turn supply the plow furrows through the land proper.

Alignment of Canals

Having determined the source of water supply and its relation to irrigable lands, the next question is the alignment of the canal. To get the best alignment there should be made a careful contour topographical map of the center irrigable area, as well as all possible routes for the diversion of water. On this trial line locations may be laid down. The more direct the location the shorter the line, the less the cost of construction and the losses by absorption. The line should not necessarily follow grade contours, for ofttimes by the inserting of occasional drops as shown in Fig. 3, and which must be well protected from washing, a more economical location may be obtained.

It is recognized by engineers that effective drainage of low-lying lands must go hand-in-hand with irrigation if it is to be carried on most satisfactorily. For this purpose also the contour map is of good service. Faulty alignment of canals results in obstructions of the natural drainage outfalls, and the use of natural drainages as irrigation channels has often been shown to be the principal cause of evil.

Grades

A steep slope may bring the canal to the irrigable lands at too low an elevation, while too great a cross-section in the diversion line will increase the cost of construction. Care is therefore necessary in proportioning the relation of cross-section to slope in order that the most suitable velocity may be maintained and the amount of material necessary to be moved be a minimum.

In different soils different slopes are necessary to produce a velocity which will not cause a deposition of silt on the one han or cause bank erosion on the other.

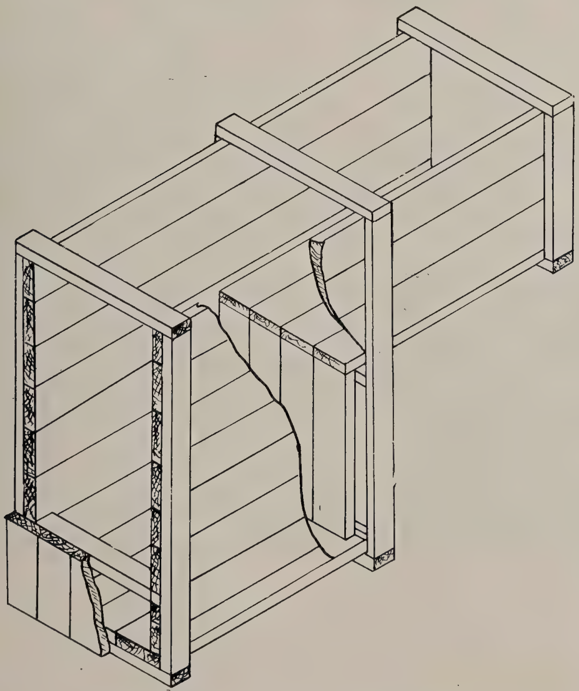

Fig. 3—Sketch of Drop, made of timber

The irrigation surveys in Saskatchewan employ the following method:

For firm gravel, rock or hardpan a velocity of from 5 to 7 feet per second.

For ordinary soil or firm loam a velocity of from 3 to 3.5 feet per second.

For light sandy loam a velocity of from 2 to 2.5 feet per second.

The grades necessary to produce these velocities depend upon the cross section. The required velocity being known, the grade may be ascertained from the Chezy & Kutter formulæ for a given discharge.

The Department have computed most useful tables by the use of the above mentioned formulæ and curves. These are used in the field. When grades and sections that are not mentioned in these tables are required they can easily be computed by plotting special curves and interpolating.

Cross-Section

The most economical sections are those with vertical sides, but these are applicable only to the firmest rock. The *best* section is of trapezoidal form.

The inner slopes of the banks may vary from 1 : 1, to as low as 4 : 1 according to the character of the soil. In ordinary firm soil a slope of 1½: 1 is sufficient.

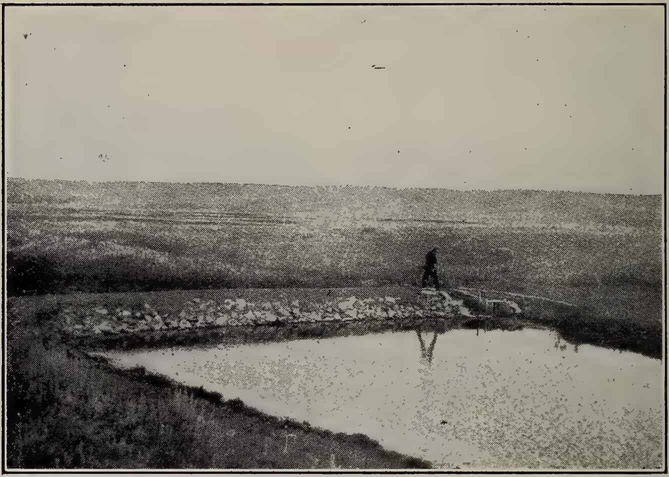

Fig. 4

The cross-section of the canal may be so designed that the water may be carried wholly in excavation, wholly in embankment, or partly in either, depending primarily on the alignment of the canal and secondarily on the character of the soil.

It is clear that when half is in cut and the other in fill the amount of material moved is a minimum. But this does not necessarily give the best service. This must be carefully investigated, for if the canal is in embankment losses from leakage are liable to occur. (This can be overcome by the placing of flumes on the fill, as can be seen on several of the working schemes in Saskatchewan, and when wholly in excavation the character of the soil should be carefully studied, as a sandy soil will cause excessive seepage losses unless the canal is properly lined, for which purpose concrete is frequently used.

The headworks of the canal system consist principally of:—

(1) Diversion dam, or weir.
(2) Sluiceways.
(3) Regulators at the head of the canal for its control.
(4) Wasteways for the relief of the canal below that point.

Diversion Dam or Weir

When irrigation is affected by means of a canal drawing its supply from a stream, it is necessary to have some means of raising the low-water level to a height sufficient to maintain the required supply in the canal. The method adopted is to build a barrier across the stream, and such barriers are of various types depending in the general way on the local conditions affecting the site selected and the materials available for construction.

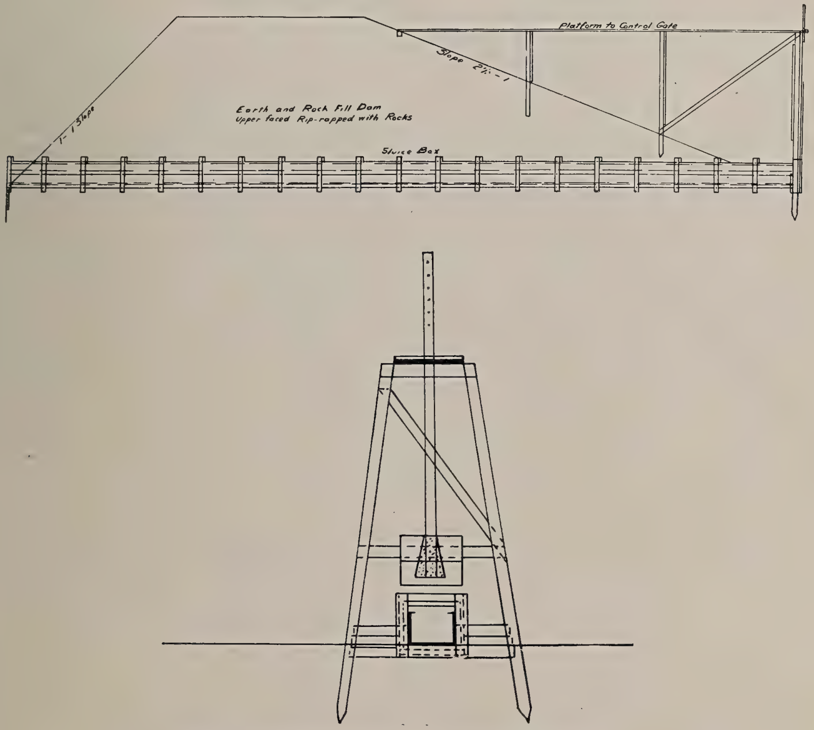

Fig. 5—Section through centre Sluice Box

It is beyond this paper to go into the theory and design of dams, but several photographs and sketches of dams and weirs in actual service in Saskatchewan are shown. The irrigation belt in that province is for the most part too far from the railroad to allow the construction of permanent structures, owing to the excessive cost, and it is therefore for this reason that the structures now in use are of timber, earth and rock which can be obtained at a reasonable price, and are near at hand.

The stream shown in Fig. 4 is one which flows only in the spring of the year and by constructing the dyke shown the irrigator can hold back considerable water, especially so in the case of where the fall in the bed is slight. The water into the ditch is controlled by means of the headgate at the end of the dyke or dam.

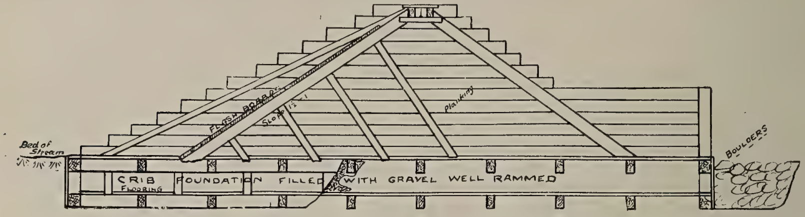

Fig. 6—Cross Section through Wasteway

Fig. 5 shows a dam used to hold the water flowing down a dry coulee from spring freshets due to the melting of mountain snows over its drainage area, etc. In this case the water is raised nearly to the top of the dam before it can be of use to irrigate the lands desired.

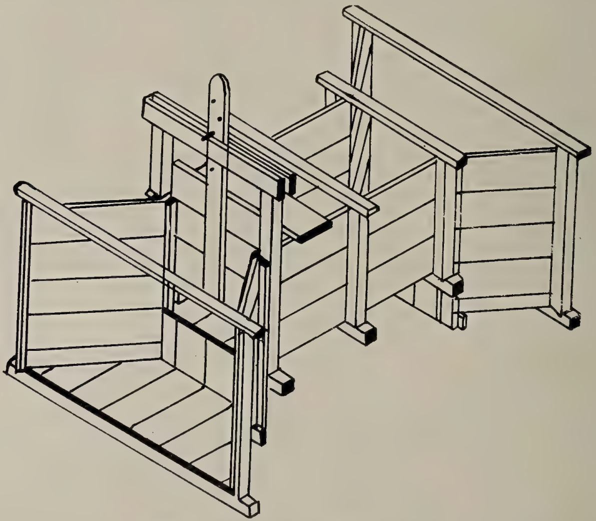

Fig. 7—Sketch of Headgate

Excessive floods are controlled by means of sluiceways through the bottom, as shown in the end view. This type of dam is often used where the stream valley is used as a reservoir, placing a sluice box at the point where the surplus water not required may be allowed to flow into stream bed below, and one or more at the inlets to the canal, since when damming up a valley there can be sluice-boxes on each end.

Fig. 6 shows a dam with open sluiceway as used in perennial streams. The height of the water level is controlled by flash boards which can be placed in or taken out with little difficulty. When the water is not required it is allowed to follow its course, but when required for irrigation purposes the water level can be raised to the height necessary for it to flow naturally into the canal which is usually at one side of the dam.

Sluiceways

Sluiceways are placed in the bottom of most well constructed dams. Their object is to remove by the errosive action of the water any sediment which may be deposited in front of the regulator. There are two classes—the open sluiceway and the undersluice. The open sluice is practically identical with the open weir. Where the weir forms a solid barrier to the channel and is only open for a short portion of its length, the latter is spoken of as a sluiceway. Undersluices are more generally constructed where the dam is of considerable height, and are commonly applied to dams which close storage reservoirs.

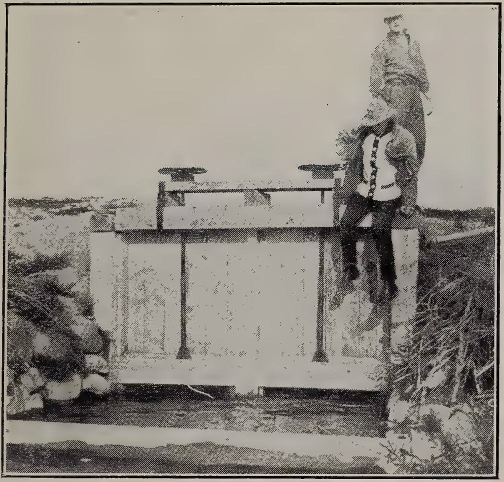

Fig. 8

Canal Regulating Gates

The regulator should be so located with relation to the dam that the water held up by the latter will pass at once into the canal. This is most successfully effected by placing the canal head immediately adjacent to the dam and building it as a part of that structure. The amount of water admitted by the regulator should be easily controllable at any stage of the stream. This can be best effected by having gates of such dimensions that they can be quickly opened or closed.

A sketch of one of the types of headgates in use on schemes in Saskatchewan is shown in Fig. 7, and also a photograph of one of the best working headgates in the district mentioned is illustrated in Fig. 8.

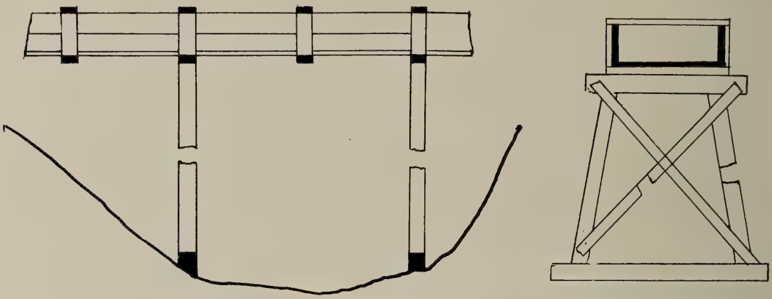

Fig. 9—Elevation and End View of Flume and Bent made of Timber, crossing a Coulee.

Wasteways

The function of the wasteway is to relieve the dam and canal in times when floods are beyond its capacity, or when the water is not required. The methods used in the construction of wasteways are important and it must be pointed out that the excavation of an overflow channel through the earth around the ends of the dam is an unwise procedure, especially where the dam is high or the excess of flow large, unless absolute provision is made by means of sheet

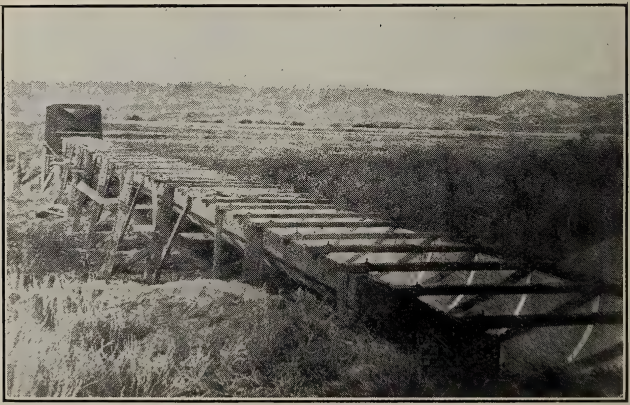

Fig. 10

piling or otherwise to prevent the bottom or sides of this channel from cutting out. In the majority of cases such spillways, constructed on various works in Saskatchewan are inadequately protected, and will, sooner or later, cut out, leaving the dam completely out of the stream channel.

Frequently the site of the dam is so located that there exists a natural overflow channel which acts as a wasteway when floods reach to nearly the height of the dam.

Flumes

Flumes on bents, as shown in Fig. 9, are made use of when it saves the cost of construction of the canal system as it would in the case where it was necessary to get across a coulee.

They are also made use of when it is necessary to cross an earth fill as already described.

When the canal encounters a steep sidehill a flume will save in the cost of construction, since a more permanent wasteway is attained.

Flumes are used where the canal crosses a stream. Flumes can be either of timber or metal.

When they cross gaps they can be supported either by bents or laid on a bridge.

Fig. 10 shows a metal flume in use on a scheme in Saskatchewan where it crosses a river and is supported by a bridge.

Reservoirs

This phase of irrigation is of ever-increasing importance in districts where the stream flow is periodic, and the engineer must realize the necessity for some such system when considering the feasibility of a scheme on any source of supply of this nature. It is quite unnecessary to take up the advantages of reservoirs where the flow in the source of supply is only spring run-off, as they are self-evident, but seen in cases where the stream has a constant low water flow the irrigator who reservoirs has a decided advantage, in the fact that he has absolute control of his methods of irrigation, i. e., he can turn a larger irrigating head into his ditches and avoid heavy seepage losses found in small streams, while the land is covered more quickly.

References

References—To the student desirous of a thorough treatment of the subject of Irrigation, the writer recommends the following:—

Wilson—Irrigation.
Engineering—Refer to Index for Articles.
Hoyt and Grever—Hydrographic Manual.
Dominion Government Reports—Progress of Stream Measurements.
R. J. Burley, '04—Instructions to Irrigation Engineers.

On Nov. 7th, T. Kennard Thomson, '86, of New York, addressed the Canadian Club of Niagara Falls, Ont., on "Bridges of the Past and Future."

BITUMEN IN MODERN PAVEMENTS

By J. B. Temple, B.A.Sc.

The importance of a suitable pavement in roadway construction is quite apparent without tabulating the obvious reasons here, and one will see that the many advantages may be summed up in the following headings:

(1) Lessening of tractive power.
(2) Cleanliness and sanitation.
(3) Establishment of permanent grade.
(4) Appearance.

The reasons that follow from the above will at once suggest themselves.

With the exception of railroad construction, there is no branch of engineering on which so much time, research and money have been spent. It is estimated that the annual expenditure for pavements in cities of thirty thousand population or more, is $1.91 per capita; or varying from $2.16 in the largest cities to $1.52 in the smaller, and that the total cost of pavements in all cities of 8,000 population and over is $500,000,000.

Now, no one kind of pavement is equally well suited for all roads; local conditions, whether it be in city, town, or rural highway, will determine the pavement, and it is obvious that even different streets in the same city will require different treatment regulated by traffic, cost, and, as mentioned above, local conditions.

Engineers have long sought for some substance that would be versatile enough to meet all these conditions, and although the pavement question is not solved, yet the substance that seemed to offer itself as a "binder" (or cement) through a great range of pavements was bitumen.

Bitumen—Its Nature and Occurrence

The name is of Latin origin applied to hydro-carbons. In its widest sense it embraces the whole range of these substances, including natural gas, petroleum, and the solid forms of asphalt, albutite, gilsonite, elaterite, ozokerite and halcheterite.

The bitumens of chief commercial importance may be grouped under the three headings: (1) Natural gas, (2) Petroleum, (3) Asphalt, and it is with the latter group that we shall chiefly deal. To the roadway engineer a "bitumen" is a hydrocarbon of tarry nature and containing little or no paraffin.

Asphalt is widely distributed throughout the world and is found in a great many rocks of different geological periods. There are differences of opinion for accounting for the presence of hydro-carbons in these rocks, but it is generally conceded that asphalt itself is formed by the evaporation and oxidization of liquid petroleum which has escaped through the outcropping strata.

Asphalt occurs in workable deposits in three types. The first type embraces the beds of nearly pure separated-out bitumen. The second type embraces occurrences of asphalt bound up in limestone or sandstone. The third type, though not as distinct, deals with the occurrence of commercial quantities in petroleum and oil shale deposits and exudations therefrom.

One of the best known deposits of the first type is the "Trinidad Pitch Lake," although the more recently developed deposits of Venezuela are said to exceed this world famous "Bitumen Reservoir." Immense deposits that may yet outclass all others are reported from, Fort McMurray, Alberta Canada.

As an example of an asphalt deposit we will take the "Trinidad Lake." In area this lake covers 99.3 acres, and the depth, while sometimes placed at twenty feet, is uncertain, and may be a great deal more. The deposits are dug out to a depth of one or two feet and transported to the refinery by means of a small railway which is laid on a corduroy of palm branches.

The excavations are quickly filled in by a plastic material which oozes up from the bottom and hardens in the hole. The surface of the lake is not level, but is made up of irregular masses separated by water and subject to independent motions. The New Trinidad Asphalt Co. export annually about 150,000 tons, and although up to the present over 2,000,000 tons have been removed, there is little evidence of the reduction in the quantity. The before-mentioned "Venezuela" deposits, which occur in the State of Bermudez, are said to be the largest yet worked, covering an area over 1,000 acres. Asphalt belonging to the first type is found in very pure quality in Cuba, principally at Cardenas, Vuelta, and Pinas del Pio. The product from Vuelta ranks among the purest natural asphalt. There are also some very old deposits of this type around the Red Sea.

For the best examples of our second type of asphalt (i.e. asphalt in linestone) we must look to Europe, as the Simmer pits in Hanover, Vorwhole in Brunswick, Travers in Switzerland, Sicily, Volga district in Russia, Canton of Neuchatel, and the neighborhood of Scyssell.

The bituminous material present in this rock ranges from 7 to 20 per cent., but for roadway material the rocks containing about 10 or 11 per cent. were found the best, so the lower grades are mixed with the high grade to bring to this constituency. From the richer rock is made a sort of asphalt "mastic," which is used for footpaths, floor, roofs, etc.

The third type of asphalt embraces the exudations of the oil shale deposits, such as are found in the petroleum fields of California. They are really semi-asphaltic oils in which the more volatile hydro-carbons (of the paraffin series) and the "burning oils" have been removed, leaving a heavy "tarry" asphaltic petroleum containing a minimum of paraffin wax.

These asphalts are sometimes produced artificially, being the residuals in the process of distillation of crude asphaltic and semi-asphaltic oil. They are then called "artificial bitumens," but it is in reality a duplication of nature's process.

There is another "bitumen" used a great deal of late in place of asphaltum, and which can hardly belong to any of the foregoing types, but is closely related to the latter. It is what we commonly call "tar," and is in itself of several types, namely, coken oven tars, coal gas tars, water gas tars, combination of water gas and coal gas tars, and asphaltic materials and tars.

We will not go into the different refining processes necessary for these different types, but might state that when the first type of asphalts is taken from the 'pitch lake" they undergo a preliminary treatment to drive off most of the water and a large percentage of the vegetable matter, clay, sand, etc., that is present.

To the refined "bitumen" is added a small quantity of residuum oil of petroleum, which makes the substance more plastic, less liable to crack, and more easier to work. This mixture is called "asphaltic cement," and is the asphalt of commerce. In appearance it is almost indistinguishable from common coal tar. It is run into barrels and shipped to the various plants and corporations all over the world, and whose chief uses in roadway constructions we shall presently take up.

Tests for Bituminous Materials

One of the first things to find in a bituminous road material under analysis is the "determination of soluble bitumen." This is done by drying the powdered specimen to be analyzed by heating it to 125 degrees centigrade for one hour. A small quantity is then dissolved in carbon bi-sulphide by intermittent decantation and the residue finally caught in an asbestos filter.

The filtrate containing bitumen is evaporated, the bituminous residue burnt and the weight of the ash obtained plus that of the residue deducted from the total weight of the substance taken gives the weight of soluble bitumen present. (Note: This is the experiment in brief, the operation being somewhat more complex.)

In somewhat similar manner the portion of the whole bitumen soluble in alcohol and ether is found. Another test is to find the loss by application of heat. This consists of enclosing the material in a box and heating at a known temperature for five hours to find the volatilization that takes place.

In connection with the "penetration," the American Society for Testing Materials has drawn up a rather concise test, which it recommends in its report of 1911. It is as follows:

"The Penetration Determination"

"The penetration of bitumen shall be the distance expressed in .01 cm. that a No. 2 needle will penetrate into it vertically without friction at 25 degrees C. under a stated weight applied for stated length of time, as follows:—

"First test of duration five seconds, weight 100 grams, if penetration is less than 10; a weight of 200 grams applied for one minute, if between 10 and 300; a weight of 100 grams applied 5 seconds, if greater than 300; penetration shall be determined under a weight of 50 grams applied to 5 seconds.

"Temperatures recommended, 0 degrees C. (32 degrees F.) and 46 degrees C. (114.8 degrees F.) and 25 degrees C. (77 degrees F.)."

One of the most important tests now in use to find the melting point consists in suspending a half-inch cube by means of a hook one inch above the bottom of a beaker filled with water at a temperature of 60 degrees F. Heat is applied in such a manner that the temperature of the water is raised 9 degrees F. each minute. The temperature recorded by the thermometer at the instant the cube of bitumen touches the bottom of the beaker is considered the melting point.

Bituminous Highway Construction

Although of only recent introduction the simplest manner that bitumen is applied to our roads is in the use of the "light" oils for the purpose of laying the dust, thus preventing a nuisance, and to some extent preserving the top of the road by keeping it from blowing away. These light oils are applied cold in much the same way as water is applied to the streets. Two applications a season will keep the road dustless and in good condition and make the highway infinitely better than if the same amount of money was spent on frequent watering. This oil sprinkling is particularly applicable to macadam and gravel roads, although every year sees more oil and less water used on all kinds of surfaces. The total cost of oil-sprinkling a road several times a season is not very much more than the old system of watering, and the results are far more satisfactory and permanent. Another way of applying these oils is in an emulsion, which mixes with the water in an ordinary watercart and is sprinkled therefrom.

There is also the more important process of applying a hot tar or asphaltic oil to act not only as a dust layer, but also as a binder for the surface of the road, making it waterproof, and thus forming a bituminous carpet or roof over it. The different oils used in this work are divided in St. Louis city specifications into four grades, arranged according to specific gravity and the use to which they are put.

The grades are as follows:—

No. 1. Residuum oil, having a gravity of 10 deg. Be., is applied cold, and is used on cinder roads and for the purpose of giving life to the surface of a road that has previously been treated with a heavier product and is becoming dusty. Being merely a dust layer it should not be considered as having any binding properties.

No. 2. Residuum oil having a gravity of 20 deg. Be. is applied hot, and is recommended for park roads and for roads that are not main arteries of travel.

No. 3. Residuum oil having a gravity of 16 deg. Be. is applied hot, and is used on the main thoroughfares having a mixed traffic and acts as a temporary binder for the mineral matter.

No. 4. An oil asphalt compound having a gravity of 12 deg. Be. is applied hot, and is recommended for any type of road, since it simply forms a binder for the mineral matter which actually bears the traffic.

The simplest method of applying these asphaltic oils to a macadam or gravel road is as follows:

The road is first graded and drained, after which a layer of sandy gravel is laid and rolled; on this is spread hot asphaltic oil, using about ¾ gallon per square yard. There is then a quantity of sand or stone chips spread over the road. The work of treating a road surface is not complete for several weeks. As soon as the road is open to traffic it is necessary to give attention to the "wet" spots that appear and apply more sand or stone chips to them.

Here are a few essential points extracted from "Gravel Surfacing and Bituminous Wearing Course Specifications of Massachusetts Highway Commission." Section 10:—

"On a sub-grade prepared as hereinbefore specified, selected gravel should be placed to the depth of 5 inches at the centre, 4 inches at the sides............

"This course shall be thoroughly watered and rolled....... so that entire surface shall conform to the cross-section......... On the surface thus prepared bituminous binder shall be applied for a width of 15 feet.........It shall be heated to specified (180 deg. F.) temperature and distributed evenly by a controllable machine. A thin layer of sand shall be then spread to such a depth that after rolling no surplus binder shall appear upon the surface."

The chief points in these specifications for asphaltic oil are:

"(a) It shall not froth when heated to 100 degrees C....... Specific gravity of at least 0.97. It shall not contain more than 1 per cent. of matter insoluble in carbon bi-sulphide.

"When 20 grams are heated in a flat bottomed dish 3 inches in diameter for 24 hours in a well ventilated oven (at 250 deg. C.) the loss in weight shall not be greater than 15 per cent., etc."

Superficial Tarring and Tar Macadam

In 1903 some French engineers carried on extensive experiments in the application of asphaltic cements, oils, pitches, and of chief importance, common tars. The simplest methods employed were much the same as described by the Massachusetts Highway Commission.

In the use of "tar" the following fundamental principles were laid down by them*:—

"1st. Superficial tarring should be done only during dry and warm weather, in order to obtain efficient and economical results.

"2nd. Road must have a dry, smooth, durable surface.

"3rd. All dust must be brushed off in order to facilitate the adherence of the tar.

"4th. After the distribution of the coat of tar it is necessary, in order to avoid a slippery surface, to apply a dressing of sand, gravel or stone chips."

All sorts of tars and pitches have been used in this work, but, according to City Engineer Rust, of Victoria, B.C., distilled tar is better than common coke oven tar. There are also many excellent patent compounds on the market. Some of these are done up in a liquid form, which may be applied cold, and which contains a volatile substance that quickly evaporates, leaving the more tarry material behind, which possesses more binding properties than an ordinary liquid "cold application" oil.

The two chief methods for "tar macadam" (or gravel) construction are, firstly, applying the bitumen by "penetration," and, secondly, by previously "mixing" the stone and tar before they are laid.

One of the very successful ways of making a bituminous-bound road by the "penetration" method is described as follows: The road is prepared as for any good water-bound macadam, special attention being given to drainage. Stone to the depth of at least four inches at the crown and three inches at the sides is spread and thoroughly rolled. Over this may be spread a thin layer of sand (not always done); then hot bitumen is applied from a sprinkler or by hand (at least one gallon per square yard). Another layer of coarse stone is applied to the depth of 2½ inches and rolled as before, and to this is applied more hot bitumen, about 2 gallons per square yard. Over this is spread from ½ to 1 inch of stone chips (or sand) and if after roller any "wet spots" appear, more chips are added. Sometimes the whole thing is finished off by a sprinkling of a light dust-laying oil.

There are many modifications of the above treatment, but in general the method is the same. It would be good engineering practice to make the road a trifle thicker than described above, particularly in the centre where the wheel traffic occurs. A total thickness of nine inches in the centre and six inches at the sides has been recommended.

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* Professor A. H. Blanchard, C.E., *Canadian Engineer*, April 13, 1911, p. 566.

To "bituminize" an old macadam road the method is quite similar. The road is scarified, graded, and about 1 inch of new stone added, which is rolled and tarred. The rest of the operation is as above described.

In the mixing method the top course of stone is tarred before it goes into the road. In this process the stone is heated to drive off all the moisture, then the hot tar applied to it and thoroughly mixed, either by hand or machine. It is then spread (to about the depth of 2 inches) to the previously prepared macadam road. It is covered with a slight coating of chips or sand and rolled. More will be said about this when we come to "bitulithic." This method gives a better road for town purposes because it is more homogeneous, the voids are filled up, and the tar is rightly proportioned; in fact, these (mixed) roads give by far the best and most satisfactory results.

A first class pitch for road work is given as follows: Coal tar, 1,100 pounds; refined tar (heavy bodied), 800 pounds; creosote oil, 100 pounds; total, 2,000 pounds.

By way of comparison it might be mentioned that the cost of tar macadam road is from 15 to 20 cents per square more than the water-bound macadam, but from what has been said the many advantages (including the lessened maintenance) are apparent.

Bitulithic

Bitulithic has many recognized advantages over the sheet asphalt for city pavements, but also has the disadvantage, that the price is somewhat high; for example, in Toronto, it costs $2,00 per square yard to lay asphalt pavement on 5 in. concrete and 1 inch binder, while 2 in. of bitulithic on the same depth of concrete and no binder costs $2.23 per square yard. However, bitulithic is an excellent pavement, and there are over one thousand miles of it in use. It has proved equally satisfactory in climates of Texas and Florida to northern climates of Manitoba and Saskatchewan.

Bitulithic is a compound of crushed stone mixed with hot bitumen in proportion necessary to fill the voids. On account of being nearly as compact as solid stone and at the same time possessing greater elasticity, it presents a surface that is very durable to destructive traffic, and being of a coarse nature it provides a good foothold and has been used with success on streets in Toronto having a steep grade.

The method of manufacture of this compound is, in brief, as follows:—

The proportions of the different sized stones that will give

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* Mr. F. S. Eppele, Co. Engineer of Mercer Co., N.J., in a paper read on January 20, 1911, before American Society of Civil Engineers, at a Road Meeting in New York City.

the best results are determined by laboratory test. Crushed stone is heated (250 deg. F.) and screened in a rotary screener, the different sizes of stone being deposited in different bins. The proportion of each of these found to be the best is weighed and if there are not enough fine-grained particles to make the best mixture, pulverized stone, sand or hydraulic cement up to 25 per cent. (but not over) is added. This is then mixed with hot bitumen and laid on a concrete foundation to the depth of 2 inches. It is then thoroughly rolled and, while still warm, a thin coating of "Warren's Quick-Drying Bituminous Flush Coat Compound" is applied. On this is spread a layer of stone chips which are immediately thoroughly rolled into the surface until it has become cool. On grades a mineral flush coat may be used in place of the liquid flush coat.

Sheet Asphalt

Sheet asphalt, for "surfacing" on city streets, was the first bituminous pavement to come into general use and favor, and although it has lost some of its popularity, owing to recent developments, yet there is still no pavement that is used so extensively the world over, and when laid by modern methods it is (just a question of argument) under a great many conditions equal to any pavement yet thoroughly tested. It possesses (with bitulithic) the advantages of being elastic and not too noisy, sanitary, easy to clean, light resistance to traffic, etc. It is also easy to repair.

Its chief faults appear to be slipperiness and liability to crack if not properly laid, and as it is generally constructed with a low crown (4½ inches up, in Toronto, for 24-ft. street), water is liable to stand in any depression in the surface, and this deteriorates the pavement in that spot, which crumbles and necessitates patching. Therefore every care is necessary to see that the finished road conforms as nearly as possible to the cross section plan, and that none of these depressions exist.

The water could be carried off successfully by using an extra high crown, but this is not practical in cities like Toronto, for in frosty and wet weather the pavement would be slippery. The tendency has been of late to reduce the crown. At one time crowns of over six inches on a twenty-four foot street were common. During the summer of 1911 new pavements were laid with four and a half inch crown. It might be stated that where two streets of different crowns meet it is necessary to strike a mean and shape the intersection so as to throw the water as evenly as possible in all directions, and in no case to let it run over the top of the road, but to lead it to the nearest culvert in the most expedient manner.

Sheet asphalt was first used in Paris in 1854 and in London in 1869. At that time it was made by grinding up the bituminous limestone (before mentioned) proportioning them so as to give about 10 p.c. bitumen. This was heated and spread on the road and formed a "mastic asphalt." Later, a compressed asphalt replaced this (rolled asphalt), which method with modification exists to-day. The first asphalts of America were made up of Trinidad asphalt, sand and stone dust, and these are the ones now in general use. The exact composition for asphalt pavement varying with the locality, climate, etc., mixtures that were found successful in America did not meet with satisfaction in Europe and vice versa.

It is necessary that the material have the most efficient ductility and stability to meet the requirements. Our climate conditions here in Toronto are exceedingly troublesome to contend with, for the heat of summer is often hovering around 100 deg. F. (which would mean a pavement temperature of possibly 130 deg.), and in winter we have registered below 20 deg. F. Mr. Clifford Richardson, in his book "Modern Asphalt Paving," states that the contraction of a pavement having a range of temperature extremes of 150 deg., would amount approximately to one inch in every one hundred feet; however the compressive effect of the traffic will compensate for some of this. It has also been shown that the contraction of an asphalt surface is less at high temperatures and greater at low temperatures. Some bitumens become brittle at above 32 deg. and some not until below zero, and after this brittle point is reached they will fracture before elongating if put into a ductility machine. This simply means that during the time when the contraction is putting the greatest strain upon the pavement, the asphaltic bitumen is rapidly reaching a point where it is incapable of further elongation in accommodating itself to the contraction effect of the decreasing temperatures. Where an asphaltic bitumen collapses readily on heat and hardens readily when subjected to cold, it is obvious that it will reach this condition in paving work before the asphaltic bitumen which has a long range between its melting and brittle points.

The above remarks apply more or less to all bituminous pavements, but are magnified in a sheet asphalt on account of its homogeneous nature and the amount of bitumen present, etc.

(*To be continued*)

E. D. MacFarlane, '09, is with the Houston Electric Railway Co., at Houston, Texas.

R. E. C. Chadwick, '06, has been appointed manager in charge of the Montreal office of the Foundation Company, Limited. Mr. Chadwick's connection with the firm has been of eighteen months' duration, although he was previously engaged with the Foundation Company, New York, as superintendent on the Woolworth Building. During 1909-10 he was bridge engineer for the city of Toronto.

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EDITORIAL

GRADUATE ASSOCIATIONS

With this issue the seventh volume of Applied Science begins. No more appropriate time or place could be chosen to endorse the spirit of organization among School men, more particularly as official bodies of men vitally interested in the Faculty of Applied Science and Engineering. Elsewhere in this issue appear accounts of annual reunions of three such associations, a fourth is shortly to be held in Toronto, and in all probability similar news from a fifth, in Vancouver, will soon be received.

At these reunions the graduates are familiarized with conditions as they exist at the University, and in the graduate body in general. They hear with pride and satisfaction the accomplishments of one kind and another in the School "family"; they discuss with concern the various needs which may have made themselves evident to them as engineers in the practical field. And, too, they meet, rub shoulders again, partake of, and thoroughly enjoy the School atmosphere which invades the gathering. It only requires the inauguration meeting to insure a revival of the old S.P.S spirit.

With a graduate body comprising considerably over 1,200 members, the time is ripe for a few more branches being formed. The Montreal branch has some fifty graduates in Quebec province in line. The Association in Timiskaming has a membership of over 60 School men. In Pittsburg about 30 reside. Vancouver is headquarters for over 50 men in British Columbia, while the branch in Toronto is accessible to over 350 graduates.

Branches do not exist in Ottawa, where 40 of our men are situated; in Winnipeg, where there are 40 more; in Calgary, where the 70 School men in Alberta might muster; or in Regina where the Regina Engineering Society has set a good example for 60 School men in Saskatchewan to follow. Hamilton is not too close to this city to have a branch organization of its own. It could include 45 resident members, and with those in Welland, Brantford, St. Catharines and adjacent towns could swell its membership to 80 or more. Chicago also has 20 School men who should organize and keep together. In short, a score of branches of the Alumni Association might well be formed, with comparatively little effort on the part of any individual, and with assurance of mutual assistance and closer fellowship. Applied Science can materially assist in such work of organization, and any information or list of addresses required is awaiting request.

NEWER FIELDS

It required a notice in the daily press recently to lead us to investigation of the number of our graduates and undergraduates who have turned to the automobile industry as a field of employment. The men who have to their credit a shop course in the electrical or mechanical industry, have, for some time, been readily assimilated by the manufacturing interests, and the demand at present approaches that for men of experience on structural steel work. In short, the trained mechanical or electrical engineer has of recent years a broad field in addition to that of the shop and the engineering office. It is in the ranks of the sales department. A well known automobile authority states that the most successful salesman is the one who possesses a thorough technical knowledge of the product he sells so that he is enabled to converse intelligently upon any phase of its construction. A thorough conception of the function of working parts, etc., creates confidence in the prospective buyer. The openings for electrical and mechanical engineers are yearly increasing, which bears out the statement that the possessor of technical training is rapidly proving a necessity in every department of the industries concerned.

ENGINEERING ALUMNI ASSOCIATION FUNCTIONS

Pittsburg Branch

On October 24th the University of Toronto Club of Pittsburg gathered at the Fort Pitt Hotel for its annual dinner and election of officers. Mr. B. A. Ludgate, of the class of '85, gave an interesting talk on "Railroading," and Mr. E. H. Porte, '11, gave a descriptive talk on the work of the Hydro-Electric Power Commission in Ontario.

The following officers were elected for the ensuing year:—President, J. G. R. Alison, '03; vice-president, O. E. Hill; secretary-treasurer, M. L. Miller, '03, 206 Suburban Ave., Pittsburg, Pa.

There are approximately 30 School men in and around Pittsburg, although not all were present at the meeting, the attendance from S.P.S. was very representative.

Montreal Branch

Montreal, Nov. 5th, 1912.

It's good to see the School we knew,
  The land of youth and dream,
To greet again the rule we knew
  Before we took the stream.
Though long we've missed the sight of her,
  Our hearts may not forget;
We've lost the old delight of her,
  We keep her honour yet.
—"The Best School of All"
—Henry Newbolt.

United by a bond of a similar training and a profession in common, about thirty School men resident in Montreal held their first annual dinner of the year at Cooper's Restaurant on Friday evening, Nov. 1. The special occasion of the evening was the visit of Dean Galbraith, who for the day had come back to the city of his birth to receive the fellowship and honor of the local association. Rumor has it that outside of some risky experiments with a certain office building elevator he spent the day quietly with a few of the senior men. The man "who discovered the law of gravitation," not the make of the elevator, was responsible for the excitement, if we are to believe W. D. Black, '09. The man that built the pyramid would have seemed a more plausible explanation to the "Bridge" men present, but no doubt Mr. Black has this in keeping for future occasion.

"There was no perceptible comment upon the meal itself, and it is hoped the committee may understand that they now have Host Cooper working up somewhere near the knee of his efficiency curve.

"After the toast to the king was honored, Mr. G. H. Duggan, '83, proposed the health of the guest of the evening, 'Our Dean,' and Mr. J. M. Robertson, '93, in appropriate words responded to the same with certain interpolations by 'Burnside' '99, of 'School' and football fame.

"The Dean replied briefly to the cheers of the men and the appreciative words of the speakers, along the thought of the benefits that they had received by being all trained together. The real and practical truth of his remarks appealed to all present. By a standing vote an expression of good wishes was sent to our men in the Cobalt region, and Dean Galbraith was asked to present the same to them when at their dinner the following week.

"It was also voted that a message of kind memories be sent Doctor Ellis, and that the Dean be asked to tell him that we hope to have him with us during the coming year.

"The officers elected for the ensuing year were:—Hon. president, Dean Jno. Galbraith; president, R. A. Ross, '90; vice-president, W. J. Francis, '93; advisory committee, J. M. Robertson, '93, J. M. R. Fairbairn, '93, W. J. Francis, '93, W. D. Black, '09, L. R. Wilson, '09; secretary treasurer, H. W. Fairlie, '10, 1577 Mance St., Montreal.

"The remainder of the evening was spent in short speeches with Mr. Ross assuming his newly acquired duties as president. There is every indication that this year's meetings will be even more successful than the previous one. So far they have tended to strengthen the pride of all our men in the "Best School of all."

Among those who were present to enjoy the occasion, according to the autographs on a menu received recently at this office were:— J. Galbraith; G. H. Duggan, '83; R. A. Ross, '90; J. M. R. Fairbairn, '93; Walter J. Francis, '93; J. M. Robertson, '93; J. T. M. Burnside, '99; D. C. Tennant, '99; G. W. Dickson, '00; W. H. Sutherland,'02; F. W. Burnham, '04; J. P. Watson, '04; A. L. Harkness, '06; J. H. Brace, '08; W. P. Murray, '08; A. M. Bitzer, '09; W. D. Black, '09; F. H. McKechnie, '09; L. R. Wilson, '09; H. W. Fairlie, '10; R. M. Walker, '10; F. Bowman, '11; J. C. Martin, '11; A. J. McFadyen, '11; C. A. Meadows, '11; E. H. Niebel, '11.

The Timiskaming Branch

That School ties remain intact even in the rush of the greatest silver mining camp of the age, and in the rapid advancement of sister camps and towns, has again been vindicated by the degree of success which attended the second annual dinner of this branch of the graduate body. On Friday evening, November 8th, the School men in the district assembled as in an old time rally to join in songs, yells and like cherished practices of former days, and particularly to impress their love and loyalty to the School and Dean Galbraith.

Although having been with the men in Montreal during the previous week at their similar re-union, and although due in New York city a few days later, the Dean again honored the Association with his presence. He brought with him an expression of good wishes and remembrance from the men who were present at the Montreal dinner.

The assembly in Haileybury included besides graduates of the School, a number of those—and genuine School men they are—whose profession could not forego their services sufficiently long to allow them to graduate, and likewise a few who purpose experiencing the graduating ceremony at a little later date. The development of the Timiskaming District is well fertilized with the technical knowledge acquired at the School. A study of the positions which they occupy shows how indispensable its graduates are to the country's business. Busy men they are, and full of admiration for the progress of the north country, but from Cochrane, Elk Lake, Porcupine, Gowganda, Cobalt and New Liskeard, they gathered into Haileybury where the Hotel Matabanick had its spacious dining room decorated like an undergraduate's den. The table was arranged in the form of a huge **T** decorated with flowers and bunting representative of the Faculty colors. The menus were also of yellow, blue and white.

The president of the Association, Mr. E. V. Neelands, with the Dean, R. H. James, and Fraser Reid on his right, and Professor Haultain, R. W. Brigstocke and S. B. Clement on the left, formed the crest of the **T**, while a double flank of School men lined up to complete the emblematic letter.

After a ceremonious toast to the King, a toast to Timiskaming was proposed by H. T. Routly, '06, who dealt briefly with the glowing agricultural and mining wealth which the district presents for the livelihood and enjoyment of the keen and ardent type of man, so marked everywhere as a companion to growth and development. The toast was ably responded to by Ben Hughes. His remarks pointed out the necessity in the management of mining interests as in any other modern business enterprise, of the conscientious and common-sensed man. The impetus of professional knowledge is oft times lessened in value if tact and judgment do not prevail. The lot of the mine manager is often a baneful one if those higher up are not equipped with a composite knowledge of the ins and outs of daily operations. High tribute was paid by Mr. Hughes to the wealth and growth of the north land, and his remarks are borne out by facts and figures. The estimated production of the Cobalt silver mines for the present year is $17,900,000, totalling $87,000,000 worth of silver during the last eight years. The camp is entering upon its ninth year in a better condition than ever before. Many of the closed down mines have been re-opened, and numerous old properties are returning to the limelight. In Porcupine the estimated production for the year is $2,000,000. worth of gold. Mills are in the process of construction, that will double the present milling capacity of the camp.

"The Faculty of Applied Science and Engineering" was toasted by Mr. B. Neilly, '07, who referred to the Faculty and its alumni as a wheel, strong and forward-moving, the Dean as the hub, the heads of the departments as felloes, and the undergraduate body as the rim. Around it all, and very essential, though farthest from the centre of the mechanism, and its strength bespeaking the value of the entire principle of motion are the alumni themselves.

Professor Haultain in replying referred to the marked efficiency of the principle on which the Dean has based his methods since the foundation of the institution. He showed the superiority of them over other and less tenable methods, in a manner as assuring as it was new to the members of the Association. His remarks were most eagerly applauded and as a view from a different pedestal created unusual interest.

Mr. H. Irwin, '09, who was present as representative of the Engineering Society and of the Toronto Branch of the Engineering Alumni Association, dealt briefly with the work of these organizations in Toronto, and with the necessity of the undergraduate and graduate bodies of the Faculty co-operating to furnish the strongest bond between them and the School.

Mr. R. H. James proposed the toast to the Engineering Profession. Although brief in his remarks, he struck a bold keynote in favor of commercial instruction in the Engineering course. He understood that the courses in the Faculty of Applied Science now included considerable instruction of this nature, and he complimented the Dean upon such timely revision. In response, Mr. H. W. Sutcliffe, on behalf of the civil engineers and Mr. H. T. Cawley representing those engaged in mining, alluded to the rapid development during the past several years of that portion of Ontario, the former commenting also upon the suitability of climatic conditions to the agricultural industry.

Then, for contrary to the toast list that to "Our Guest" had purposely been postponed, Mr. Alex. Smith, in a reminiscent mood, reviewed several instances during his School career, typical of those of every student, and dealing with occasions of personal contact with the Dean. He brought out most skilfully the dominant features of the undergraduate's impression of the man, gained by the same occasional associations with him. The Dean, upon rising to reply was given a reception characteristic of the esteem in which he is held in the hearts of Timiskaming School men. His remarks dealt lightly with academic affairs. He referred, however, to the excellent work accomplished by Major R. W. Leonard, the honorary president of the Timiskaming Branch of the Association, as a member of the Board of Governors of the University. His remarks were for the most part in praise of the great advance Northern Ontario was making.

"Sister Institutions" was proposed by Mr. H. G. Kennedy, who believed that an association combining engineering graduates of all universities would be very advantageous to the profession in Canada. Mr. S. B. Clement, representing McGill University, in reply, commended the suggestion, and complimented Mr. Neilly upon his apt reference to the Faculty as a great wheel, with the Dean at its center. He furthered the exemplification by observing that the progress of engineering among other professions in Canada would be greatly enhanced by the united endeavours of the three or four similarly existing wheels.

Mr. Fraser Reid, replying for Queen's, dwelt upon his association years ago with Professor Haultain while the latter was engaged directly in mining, and observed this companionship as having been one of the most profitable he had ever experienced. Mr. R. W. Brigstocke responded for R.M.C. and Mr. Weede later replied for his own College, the Colorado School of Mines.

A toast to the ladies was likewise observed and responded to, the information transpiring of the advent into the prospecting field of a number of ladies in the farther north.

The success of the dinner firmly assures its annual recurrence. Much credit is due to the executive, and to the Dinner Committee consisting of Messrs. Routly, Cawley, and Campbell.

School men of Timiskaming present were:—President E. V. Neelands, manager Hargraves Mine, Cobalt; Secretary-treasurer H. W. Sutcliffe, of Sutcliffe and Neelands, surveyors and engineers, New Liskeard; B. Neilly, manager, Penn-Canadian Mines, Cobalt; S. Thorne, manager, Silver Bar Mine, Cobalt; A. D. Campbell, engineer, O'Brien Mines, Cobalt; H. T. Routly, of Routly & Summers, surveyors and civil engineers, Haileybury; G. F. Summers, of Routly & Summers, Haileybury; A. D. McDonald, engineer, Penn-Canadian Mines, Cobalt; H. G. Kennedy, engineer, Cobalt Lake Mines, Cobalt; C. G. Titus, engineer, Timiskaming Mines, Cobalt; J. H. C. Waite, engineer, Drummond Mines, Cobalt; Jno. A. Brown, engineer, Routly & Summers, Porcupine; H. E. Cawley, mining engineer, Cobalt; E. W. Neelands, of Sutcliffe & Neelands, New Liskeard; Geo. Johnston, mining engineer, Elk Lake; H. M. Carroll, engineer, Routly & Summers, Haileybury; L. J. Duthie, engineer, McEnhaney Mines, Porcupine; Alex. Smith, of Carter & Smith, mining engineers, Porcupine; W. R. Nickle, Transcontinental Ry., Cochrane; G. Pilly, Transcontinental Ry., Cochrane; P. Maher, Timiskaming and Northern Ontario, Haileybury; A. D. Wylde, engineer, Haileybury; Frank Perry, mining engineer, Haileybury.

The guest list included: Dean Galbraith, Prof. H. E. T. Haultain; Mr. S. B. Clement, superintendent of maintenance, T. & N. O. Ry. (representing McGill University); Mr. Fraser Reid, mill superintendent, Coniagas Mines (representing Queen's University); Mr. R. W. Brigstocke, manager Drummond Mines (representing Royal Military College); Mr. Weede, engineer Townsite Mine (representing Colorado School of Mines); Mr. H. Irwin, Toronto (representing Toronto School men); Mr. R. H. James, manager O'Brien Mines, Cobalt; Mr. R. Taylor, manager Right-of-Way Mine; Mr. Gordon Kennedy, Northern Concentrators, Cobalt; Mr. R. F. Kellock, Cobalt; Mr. Ben Hughes, Toronto "Globe;" Mr. Carl Green, Cobalt "Daily Nugget."

THE INDUSTRIAL CHEMICAL CLUB

The first monthly dinner for the year was held recently after an instructive trip through the plant of a large local soap-making industry. An important part of the dinner was a live discussion on the subject of "The Future of Chemists in Canada and the United States," opened by Mr. D. J. Huether, '08. After touching upon the various industries in which the chemist is successfully employed, and the many different branches of industry which are persistently demanding his attention, Mr. Huether, as an exemplification of increased efficiency in manufacturing processes under the chemist's supervision, cited numerous cases where a saving of hundreds of dollars per day was attributable to a change of operative methods recommended by the chemical engineer.

WHAT OUR GRADUATES ARE DOING

L. C. Mitchell, '11, has recently accepted a position as chemist with the German-American Sugar Co., of Bay City, Mich. He was previously with the Guantanamo Sugar Co. in Cuba.

N. H. Manning, '09, is Toronto manager of the Canadian Inspection Co.

W. R. Worthington, '04, is assistant engineer in charge of sewers for the city of Toronto, succeeding J. D. Shields, '94, who has just resigned. Mr. Shields is severing his connection with the staff of the city engineer to engage in private practice.

Among the recent changes in the staff of the Faculty of Applied Science and Engineering may be noted the following:

Mr. R. W. Moffatt, '05, formerly of the Department of Drawing, has resigned and has accepted a position as lecturer in civil engineer ing at the University of Manitoba.

Mr. L. B. Taylor, lecturer in mechanical engineering, has also resigned and has been succeeded by Mr. M. B. Jackson, a graduate of McGill University.

Mr. W. C. Blackwood, '06, of the department of physics, has been engaged permanently on the teaching staff of the Technical High School. Mr. Alan Fraser, '10, of the same department last year, is a division engineer for the Canadian Northern Railway. Mr. G. L. Wallace, '11 succeeds Mr. Blackwood as demonstrator.

W. R. Key, '09, last year in the department of applied mechanics has A. Young, '11 as his successor. Mr. Key is with Routly & Summers, roadway engineers.

A. G. Code, '10, R. V. Macauley, '11, and R. Taylor, '11, are new members of the staff in the electrical engineering department J. H. Parkin, '11, is in the mechanical engineering department. In drawing and architecture the following are among the sessional appointments: F. E. Watson, '11, G. K. Williams, '10, W. J. T. Wright, '11, and G. R. Workman, '09. In surveying the new instructors are: J. A. Macdonald, '10, L. A. Badgley, '11, and W. J. Baird, '10. M. Pequegnot, '08, and H. Hyatt, '11, are in charge of the practical work in the structural engineering course mentioned editorially last issue. In the department of chemistry D. J. Huether, '08, A. R. Bonham, '11, and R. A. Cunningham, a graduate of Edinburgh University, are new staff members.

DIRECTORY OF THE ALUMNI

Giving each month, in alphabetical order, the location of a number of the graduates. The entire list will be reviewed in the twelve issues beginning November 1912.

The graduates will confer a favor by advising us of any and all instances where the list is not up-to-date. Addresses unknown, or no longer correct, are hard to eliminate entirely from our records. If graduates will see that the information given about *themselves* is exactly as it should be, and that that concerning their class mates is also correct to the best of their knowledge, the department will soon be most reliable.

A

Acres, H. G., '03, is associated with the Hydro Electric Power Commission, Toronto, as assistant engineer.

Adams, J. H., '10, is in Summerland, B.C., in the employ of the Kettle Valley Railway as surveyor.

Adams, O. F., '10, is taking his fourth year in the Faculty of Applied Science and Engineering, University of Toronto.

Aitken, J., '11, is assistant chemist for the Canada Cement Company in its manufacturing plant at Kilbourn Siding, Que.

Akers, H. G., '08, is a member of the firm of Akers, Mason & Bonnington, chemical engineers, Toronto.

Alexander, J. H., '04, is engaged in engineering and contracting in Winnipeg.

Alison, T. H., '92, is with the Bergen Point Iron Works, Bayonne, N.J., as chief engineer and secretary of the firm.

Alison, J. G. R., '03, is in the employ of the Riter-Conley Manufacturing Co. of Pittsburgh, Pa.

Allan, J. R., '92, is in Renfrew, Ont., carrying on a general engineering and surveying practice.

Allan, J. L., '00, is in Dartmouth, N.S., on Government service, as office engineer on the construction of a branch line from Dartmouth to Dean, N.S.

Allan, L. B., '11, until recently with the Roadways Dept., City Hall, has accepted a position in journalistic work.

Allen, F. G., '07, was assistant to chief engineer B. F. Sturtevant Co., Hyde Park, Mass., until recently. We do not know his present address.

Allison, C. B., '08. His present address is unknown to us.

Alport, F., '08, until recently resident engineer at Redditt, for the Transcontinental Railway, is taking a post graduate course this year in the Faculty of Applied Science.

Amos, W. L., '06, is with the Toronto Electric Light Co. in their engineering department, as their chief draughtsman.

Amsden, W. G., '10, is at Neepawa, Man., superintending the waterworks and sewerage development for Chipman & Power.

Anderson, A. G., '92, is a hardware merchant at Port Dover, Ont.

Anderson, F. J., '07, is at Niagara Falls, Ont., with Anderson & Barry, engineers and surveyors.

Anderson, R. M., '08, is a member of the firm of Speight & Van Nostrand, engineers and surveyors, Toronto.

Andrews, E., '97, is resident engineer for the Maenofferen Slate Quarry Co., of Portmadoc, North Wales.

Angus, H. H., '03, has received an appointment to the staff of the Canadian Domestic Engineering Co., Toronto.

Angus, R. W., '94, is professor of mechanical engineering, University of Toronto.

Apsey, J. F., '88, is assistant division engineer to the Baltimore Sewerage Commission.

Archer, E. G., '11, is in the employ of the Canadian Westinghouse Co., Hamilton, Ont.

Ardagh, A. G., '93, has a private practice in Barrie, Ont., land surveying and engineering.

Ardagh, E. G. R., '00, is lecturer in chemistry, University of Toronto.

Arens, A. H., '06, is resident engineer and mine surveyor for the Inverness (N.S.) Railway & Coal Co.

Arens, E. G., '09, is in Hamilton, Ont., with the Canadian Westinghouse Co., engineering department.

Arens, H. W., '03, deceased.

Arens, J. R., '08, is with the Dunlop Rubber Co., Toronto, as chemist.

Armer, J. C., '06, is manager of the *Canadian Manufacturer* Publishing Co., and secretary-treasurer of the Commercial Press, Limited, Toronto. He is president of the Engineering Alumni Association, Toronto Branch.

Armour, R. H., '05, is in New York City with the Westinghouse Electric and Manufacturing Co.

Armstrong, H. V., '09, is at Estevan, Sask., superintending the installation of a water power plant for Chipman & Power, Toronto.

Armstrong, J., '95, is district engineer for the Grand Trunk Pacific, at Quebec.

Ashbridge, W. T., '88, is at Kelowna, B.C., where he has designed and superintended the construction of waterworks and electric light plant.

Augustine, A. P., '07, is in Vancouver, B.C., and is engaged in land surveying.

Austin, E. T., '09, is in the employ of the Mond Nickel Co. at Coniston, Ont., as assistant engineer.

Aylesworth, C. B., '05, previously in the Canadian Westinghouse Co.'s drafting room, has no address with us at present.

B

Badgley, L. A., '11, recently on hydrographic survey work, with the department of the Interior, is a demonstrator in surveying, University of Toronto.

Bain, J. A., '00, is in Ottawa, as structural engineer, Department of Public Works.

Bain, J. W., '96, is associate professor of applied chemistry, University of Toronto.

Baird, J. A., '10, is in practice with his father in surveying and general engineering, Leamington, Ont.

Baird, W. J., '10, recently with R. R. Grant, O.L.S., is a demonstrator in surveying, University of Toronto.

Baker, M. H., '06, is city engineer for St. Thomas, Ont.

Baldwin, F. W., '06, is engaged with Graham Bell, Esq., Hammondsport, N.Y., and Baddeck, N.S., in experimentation and manufacture of aeroplanes.

Ball, E. F., '88, is chief assistant engineer of resurveys, N.Y.C. & H.R. R.R. Co., New York City.

Ballantyne, H. F., '93, is in New York, where he has for some years been carrying on an architectural practice.

Banting, E. W., '06, is a demonstrator in surveying, University of Toronto.

Barber, Frank, '06, is engineer for York county, and is carrying on a consulting practice in bridge and concrete engineering.

Barber, H. C., '08, is assistant engineer of the Hamilton (Ont.) Hydro-Electric Department.

Barber, H. G., '02, is with the Department of the Interior, Topographical Surveys Branch, Ottawa.

Barber, T., '99, is hydraulic engineer for Chas. Barber & Sons, manufacturers of turbine water wheels and accessories, Meaford, Ont.

Barber, W., '05, is with the city of Toronto, in the roadways department.

Barker, H. F., '94, is in the city. He is a member of the firm of Godson Paving Co.

Barley, J. H., '00, is in the engineering department Canadian Westinghouse Co., Hamilton, Ont.

Barnett, H. A., '10, is with the Canada Pacific Railway Co. construction department, Toronto.

Barrett, J. H., '04, is with the Wm. Davies Co., Limited, Toronto, as superintendent.

Barrett, R. H., '01, deceased.

Barry, W. H., '09, is a member of the firm Anderson & Barry, engineers and surveyors, Niagara Falls, Ont.

Bartlett, E., '08, is engaged in private practice as engineer and surveyor, in Medicine Hat, Alta.

Bartley, T. H., '11, is in Mutana, Sask., engaged on Government resurvey work, under R. C. Purser, '06.

Bates, M., '06, deceased.

Batten, H. L., '11, is engineer for the Inspiration Copper Co., Miami, Arizona.

Beatty, H. J., '91, resides in Eganville, Ont., as an engineer and surveyor.

Beatty, J. A., '03, is a member of the firm of Morrow & Beatty, contractors, Peterboro, Ont.

Beauregard, A. T., '94, until recently laboratory engineer, Public Service Corporation, New Jersey, is now residing in Gravenhurst, Ont.

Beckstedt, R. D. S., '09, is in the employ of the Cataract Power Co., Hamilton, Ont., in their testing Dept.

Bedford, F. J., '08, is at Lakefield, Ont. We do not know his professional engagement.

Begg, W. A., '05, is townsite inspector for the Department of Public Works at Regina.